AN INVESTIGATION INTO EXPECTED DURATION ESTIMATION AS USED AS PART OF THE TIME MANAGEMENT PROCESS

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

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ABSTRACT

The scheduling component of the time management process was used as a 'paradigm' to develop a process model of expected duration estimation. The main contention of the model is that people will attempt to estimate the expected duration of an upcoming event by 'reflecting' back upon memories of similar events. Although it is presumed that this 'reflection' will often involve reconstructing event/s from memory traces they will often appear (to the estimator) to be a verisimilar representation of a specific event. A time management context was also utilised to conduct four experiments that explored components of the expected duration estimation model. Experiment 1 explored the effect that presenting a highly salient, similar to-be-estimated task had on a subsequent task estimate. Participants in this experiment tended to allocate significantly less time to the completion of a task if they had previously estimated the expected duration of a similar, shorter task. Conversely, they tended to allocate significantly more time to the completion of a task if they had previously estimated the expected duration of a similar but longer task. Experiment 2 investigated the importance of appropriate temporal boundaries when making an expected duration estimate. Participants in this experiment were required to provide expected duration estimates for tasks under varying remote temporal boundary scenarios. It was found that remote externally derived temporal boundaries significantly affect expected duration estimates. Experiment 3 and 4 looked at the effect that the tendency to provide estimates in the form of prototypical temporal values had on accuracy. Additionally, these two experiments investigated whether chunking tasks together for scheduling purposes would help overcome estimation inaccuracies presumed to be partly due to the predisposition to round estimates to prototypical temporal values.

The majority of estimates from both experiments could be categorised as being prototypical temporal values. The chunking together of the tasks used in Experiment 3 resulted in a significant increase in estimation accuracy, however it had the opposite effect in Experiment 4, which utilised somewhat longer tasks.

Introduction

"Time is nature's way of keeping everything from happening at once"

(source unknown, cited in Block, 1989, p.340)

The primary purpose of this PhD thesis is to provide a greater understanding of the processes involved in making expected duration estimates. The scheduling of to-be-completed tasks, as part of the time management process, was used as a 'paradigm' to develop a process model of expected duration estimation. This paradigm was also utilised in order to conduct four experiments that explore components of the proposed model. These four experiments explored the effect that individual presentations have on updating schematic event memory (predicted to be an important source of information when making an expected duration estimate), the importance of providing appropriate temporal boundaries, and the effect that people's tendency to provide estimates in the form of 'prototypical' temporal values had on estimate accuracy.

The thesis begins by highlighting the importance of the concept of 'time' to humanity. Chapter 1 outlines the inherently perplexing nature of time and how humanity has struggled to understand this inescapable, yet elusive, concept. The second part of this chapter introduces the important concept of 'psychological time'.

As very little research has been conducted specifically addressing expected duration estimation, a thorough investigation of duration estimation research in general is conducted in Chapter 2 in order to build a framework for understanding this specific type of estimation. This chapter provides a general introduction to duration estimation research. It includes a discussion of the importance of understanding the human duration estimation process and also outlines the main research paradigms. Leading on from this overview of duration estimation research, the chapter reviews the main theories that attempt to explain various types of duration estimation. This chapter also includes a discussion of individual differences in relation to duration estimation ability.

Before introducing my model of expected duration and associated experiments, a real-world 'paradigm' in which to base this work needs to be introduced. Chapter 3 summaries the time management literature, with emphasis placed on the task-scheduling component of this process. This chapter demonstrates the importance of making accurate expected duration estimates for the time management process, and ultimately psychological well-being.

Chapter 4 introduces my model of expected duration estimation. The four main components of the model are discussed individually: (1) searching memory for similar tasks or events to the task or event which is to be estimated; (2) gauging the appropriateness of the remembered tasks or events; (3) what has been labelled the 'retrospective process'; and (4) lastly what has been labelled the 'expected process'. During this discussion the four experiments undertaken to investigate components of the model are introduced.

The following three chapters describe the four experiments. Chapter 5 describes Experiment 1 which demonstrates that a highly salient individual presentation of a similar task can up-date schematic event memory information from which the estimation of a subsequent task is derived. Chapter 6 describes Experiment 2, which addresses the effect that remote temporal boundaries have on expected duration estimates. Although the general thrust of the literature in the area tends to suggest that temporal boundaries inhibit accurate duration estimation, the present experiment demonstrates the importance of having appropriate temporal boundaries when making expected duration estimates. Chapter 7 describes Experiments 3 and 4 which suggest that the patterns of over and underestimation found in past expected duration estimation research can at least be partly explained by the tendency to estimate prototypical temporal values. Results from Experiment 3 suggest that the overestimation of relatively short duration tasks (the 2-10 minute range) is predominately (or at least significantly) due to the tendency to provide estimates in multiples of 5 minutes. Further, in line with the above reasoning it is demonstrated that grouping these relatively short duration tasks for scheduling purposes results in significantly less overestimation and hence more accurate estimates. The fourth experiment utilising longer tasks (20-40 minutes), again finds evidence for a tendency to report prototypical temporal values. However for these longer tasks grouping resulted in less accurate estimates.

Finally, Chapter 8 provides concluding comments and discussion concerning my model and the four experiments. Discussion revolves around the model's application, including the experimental results, to the improvement of the task scheduling component of the time management process. Suggestions for future research are also provided.

Chapter 1

The conceptualisation of time

Duration estimation is embedded within the much wider concept of 'time' and temporal experience. In light of this integration, before embarking on a discussion concerning duration estimation, it is important to understand some of the history concerning time and its relationship to humans. This chapter begins by providing a brief introduction to the all encompassing, and somewhat perplexing, nature of time in relation to our own existence. The chapter concludes with a discussion of the important concept of psychological time.

1.1 Time and humanity

Time is probably humanity's most important dimension (Navon, 1978), it has puzzled and intrigued our species since the dawn of civilisation (Szamosi, 1986). This fact is evidenced throughout history. Saint Augustine (1949), in writing his 'Confessions' around 400AD stated: "When then is time? If no one asks me I know, but if I wish to explain to him who asks I know not" (p. 26). More recently, Whitehead (1861-1947, cited in Mays, 1959) noted that contemplation of time forces a recognition of a sense of limitation of the human mind. The complexity and abstraction of the concept of time is evident by the way it is defined. The first of the 51 different definitions given by the Collins Concise Dictionary is "the continuous passage of existence in which events pass from a state of potentiality into the future through the present, to a state of finality in the past" (Hanks, 1989, p. 1239).

Clocks have become so ingrained into our everyday lives that it seems somewhat absurd to think of them as being metaphors of time – 'they are time'! Although devices for measuring time are somewhat omnipresent, this has by no means always been the case. The formal representation of time, the most ubiquitous example being the clock metaphor, was ultimately formalised in the 17th century with the help of Newton's mechanics (Dohrn-van Rossum, 1996). Furthermore, time in the precise terms that we have come to take for-granted is arguably a recent phenomenon, as Aldous Huxley (cited in Campbell, 1990) points out:

> "To us, the moment 8:17 am means something –something very important, if it happens to be the starting time of our daily train. To our ancestors, such an odd eccentric instant was without significance – did not even exist. In inventing the locomotive, Watt and Stevenson were part inventors of time." (p. 211)

In fact, to our prehistory ancestors 'cutting up' and displaying time would probably be a terrifying idea. A fact recognised in S. M. Stirling's recent novel 'Island in the Sea of Time' whereby an American island is sent back to a historically accurate 1250 BC. The following abstract describes the experience of one prehistory local's view towards the Americans' clocks:

> "The temple tower had another one of those clocks in it. He shuddered. Cutting away your life, second by second, the way the Crone's knife did at the

last when she put you in the Cauldron. Seconds, he thought. Only the Amurrukan (sic) would divide time into pieces like that, like a cook dicing onions for soup." (Stirling, 1998, p. 192-193)

Somewhat surprisingly, the conception of time as a quantifiable and uniform entity that operates independently to the motions taking place in it appears only to have been realised relatively late in human history - emerging around the 12th century with musical notations denoting different intervals (Szamosi, 1986). The cultural evolution concerning reasoning about time implies that the way we conceive of time should not be taken as self-evident. For example, although both children and adults typically appear to readily perceive the unidirectionality of time (Levin & Zakay, 1989) this is not universal (Navon, 1978). Additionally, Freud (1952) noted that during dreams and imagination, time's arrow can change direction.

To summarise, although time is one of the most important concepts in our lives it is also one of the most poorly understood (Zakay, 1989). At the root of the problem is the difficulty we have in conceptualising time. As Gibson (1975) puts it, "events are perceivable, but time is not" (pp. 195).

1.2 Psychological time

Given the richness of the concept it is not surprising that 'time' sheds light on a wide variety of psychological areas including development, cognition, perception, psycholinguistics and education (Levin & Zakay, 1989). Similarly, all behaviour is under the control of time (Michon & Jackson, 1985). For example, Wessman (1973) concludes that an awareness of the temporal aspects of one's environment is essential to the development or organisation of many of our most important cognitive functions. Furthermore, he argues that the way we order and structure our lives with respect to time is a basic feature of our personality.

Likewise, the classic work of Ornstein (1969) clearly demonstrates time's importance. "Time is one of the continuing, compelling and universal experiences of our lives, one of the primary threads which combine in the weave of our experience. All our perceptual, intellectual and emotional experiences are intertwined with time" (Ornstein, 1969, p. 15).

The central interest of this thesis is psychological time, namely time as it is processed by the human mind (Levin & Zakay, 1989). More specifically, psychological time is the processes by which a person adapts to, and represents, the temporal aspects of environmental proceedings (Block, Zakay, & Hancock, 1999). Psychological time is essential for humans (and many other organisms) to orientate in their surrounding world, enabling them to adaptively organise themselves so that their behaviour remains tuned to the sequential relations of their environment (Michon, 1985; Zakay, 1990).

One of the paradoxes about human time perception is that it involves the perception of something 'nontemporal' (Poynter, 1989). Part of this paradox is the fact that while other forms of perception involve the transduction of physical energy by a sensory organ, thus providing a physical correlate of what is perceived, a similar process is not readily identifiable with the perception of the passage of time. There appears to be no single sensory organ or perceptual system that can fully account for the richness and complexity of psychological time (Poynter, 1989; Zakay & Block, 1996).

One of the first psychologists to address the issue of psychological time was William James (1890) who provided the following insight: "In general a time filled with varied and interesting experiences seems short in passing, but long as we look back. On the other hand, a tract of time empty of experiences seems long in passing, but in retrospect short" (p. 408). The belief here was not that time accelerates but that our subjective estimation of it changes. A fact that is adeptly described in the following description of a battle: "Four minutes, more or less. Time always went like that in a fight, stretching like a thread of thickening maple syrup while you waited for it to start, then blurring past once it got started" (Stirling, 2000, p. 260).

More recently, a large and complex literature has developed looking at philosophical and scientific issues surrounding psychological time (e.g., Damasceno, 1996; Gould, 1988; Grondin, 2001; Hardcastle, 1996; McGrath & Kelly, 1986; Shmotkin & Eyal, 2003). More specifically, the psychological literature has addressed issues such as time perception and estimation (e.g., Ornstein, 1969), time perspective and future orientation (e.g., De Volder & Lens, 1982; Nuttin, 1985), and the psychopathology of time (e.g., Melges, 1982). One aspect of this research into psychological time is our ability to estimate duration (e.g., Block, 1990), and it is to this topic that attention is now directed.

Chapter 2

An introduction to duration estimation research

This chapter reviews research that has addressed duration estimation. Included is a description of the two predominate research paradigms – prospective and retrospective – and a potential third category - expected. Included in this discussion are the typical durations that are researched. Subsequently, four potentially important individual differences are discussed in respect to duration estimation accuracy – age, gender, IQ, and culture. Lastly, the main types of models, which have been developed to explain and understand duration estimation, are introduced.

2.1 The importance of understanding human duration estimation

As has been mentioned, there is a relatively rich history of the study of many aspects of psychological time (Block, 1990; James, 1890). Early research focused on duration estimates for their obvious intrinsic interest (see Woodrow, 1951). More contemporary researchers have studied duration estimates to help understand many psychological, memorial, and attentional processes (Block, 1990). Block (1990, pp. 9) states "if an event or episode persists longer than a few milliseconds, people experience, remember, and may therefore be able to judge duration."

Probably the most frequent use of time concerns cognising in the 'specious present' within a range of a few seconds. However in order to represent their external environment, humans are regularly required to make duration estimates ranging from milliseconds to years (Poppel, 1988). In light of this fact, experience of duration is the most researched of all aspects of psychological time (Block & Zakay, 1997). Fraisse (1984) distinguishes between estimation and perception of duration. Perception, he suggests, only involves the psychological present (100ms – 5sec), while longer intervals involve a long-term episodic memory mechanism. He suggests that estimation occurs when memory is used either to link past events or to associate a moment in the past with a moment in the present. Likewise as Richelle (1996) points out:

> "Estimation of duration in humans is not a primitive intuition of the passage of time, but on the contrary it is the result of an elaborate inference process, which takes into account a number of variables such as number and quality of events occurring during the estimated time period, and the complex relationship between other aspects of things going on." (p. 10-11)

2.2 Research paradigms

Traditionally there have been two main types of duration estimation paradigms that are of interest to researchers (Burt & Kemp, 1994). James (1890) first made the important distinction between prospective and retrospective time, which are now referred to as the 'prospective paradigm', and the 'retrospective paradigm'. Perceptively, James (1890) went on to add that duration in passing lengthens when "we grow attentive to the passage of time itself" (p. 626), whereas duration in retrospect lengthens as a function of "the multitudinousness of the memories it affords" (p. 624). It is important to point out that although their names appear to imply otherwise, both the prospective and retrospective paradigms involve a person judging the duration of a past event/period of time.

The prospective paradigm, or 'experienced time' (Block, 1990), involves situations where the person knows in advance that they will be required to make a duration judgement. There are a number of commonly used duration estimation methods used in this paradigm (see Fraisse, 1984). For example, using the method of 'verbal estimation', a participant might be informed that they will be required to estimate to the nearest minute or second how long an upcoming event is (see Fraisse, 1984). The other popular method is 'reproduction' which is where a participant is asked to reproduce an objectively measured duration using a subjectively defined time duration. For instance, the participant may be exposed to an event lasting two minutes then asked to delimit a second duration (by saying start and stop) to estimate the target duration (see Fraisse, 1984). Overall, there appears to be no significant difference in the patterns of results as a consequence of method from studies using verbal estimation or reproduction (Block & Zakay, 1997).

The retrospective (remembered duration) paradigm involves situations where the person is not aware until after the time period is over that an estimation of its duration will be requested (see Block, 1990). In general, more research has been conducted using the prospective than the retrospective paradigm (Block & Zakay, 1997). One of the reasons for this is that after a participant has been asked to make a retrospective duration estimation he or she will be aware that future duration estimates may be required rendering these prospective in nature. However, recent studies by Boltz and colleagues have demonstrated ways to partly overcome this problem by using multiple event presentations before the duration estimation phase (e.g., Boltz, 1998a; Boltz, 1998c; Boltz, Kupperman, & Dunne, 1998). Given the fact that many everyday actions require retrospective 'type' duration estimates there is a need for further investigation using the retrospective paradigm, a view that is backed by leading theorists (e.g., Block et al., 1999).

Despite one of the first studies to compare these two different paradigms reporting no significant differences (Bakan, 1955), overall prospective estimates tend to be more accurate than retrospective ones (e.g. Block, 1992; Block & Zakay, 1997; Brown, 1985). Most contemporary research reports distinctly different patterns of results for the two paradigms and a wide range of theorists argue that different mechanisms are involved (e.g. Block, 1992; Block & Zakay, 1997; Brown, 1985; Grondin & Macar, 1992; Macar, Grondin, & Casini, 1994; Nichelli, 1996). For example, Block (1992) demonstrated a 'double dissociation' showing that prospective duration estimates decreased as a processing task became harder, while having no significant effect on retrospective duration estimates. Conversely, another study by Block (1992) found that retrospective duration estimates increased in relation to the number of tasks the participant performed during the interval, while having no significant effect on prospective duration estimates. Although duration estimates in these studies tended to be underestimates, a recent meta-analysis conducted by Block and Zakay (1997) suggests that overall, prospective duration estimates tend to be longer, as well as less variable than retrospective ones. It is suggested that processing difficulty selectively influenced prospective duration estimates, while duration length and stimulus complexity selectively influenced retrospective duration estimates (Block & Zakay, 1997).

Relatively recently Burt and Kemp (1994) highlighted a potential third category of duration estimation – expected duration. This 'paradigm' requests all duration estimates for an activity before it is actually performed – a task which individuals often undertake in everyday life before engaging in an activity (Burt & Kemp, 1994). For instance, while at work people are often required to schedule the completion of an upcoming event by 'blocking-out' the time they think will be required in their diary. Similar to Burt and Kemp (1994), it will be argued in this thesis (see Chapter 4) that, with the addition of a number of steps, the expected duration estimation process is heavily reliant on retrospective duration estimation processes.

Another important issue to consider is the length of the objective duration utilised in research. Most duration estimation research is concerned with relatively short durations of less than five seconds, and rarely exceeds two minutes (Block & Zakay, 1997; Block et al., 1999; Fraisse, 1984). For example, the 20 prospective studies used in Block, Zakay and Hancock's (1999) recent meta-analysis all used objective durations under 100 seconds. Fraisse (1984) suggests that three distinctly different processes are involved in three categories of objective durations: less than 100 milliseconds; 100 milliseconds to five seconds; and, above five seconds. Although the validity of these demarcations is less than clear it highlights the importance of utilising an appropriate objective duration in order to explore hypothesised temporal processes (Zakay, 1990).

Some of the earliest empirical investigations of duration estimation were undertaken by Vierordt (1868, cited in Yarmey, 2000) and Horing (1864, cited in Fraisse, 1963) who found that short objective durations tend to be overestimated, whereas longer ones tend to be underestimated. This is commonly referred to as

'Vierordt's Law'. Empirical support for this 'law' has indeed been found - people do tend to overestimate short durations lasting up to a few minutes (e.g., Loftus, Schooler, Boone, & Kline, 1987; Orchard & Yarmey, 1995), while underestimating longer events lasting 20 minutes or more (e.g., Yarmey, 1990).

It is worth noting at this point that the terms over and underestimation are potentially problematic (Block, 1989; Eisler, 1996; Hancock, Arthur, Chrysler, & Lee, 1994; Wahl & Sieg, 1980). Eisler (1996) suggests that the terms are often used in an ambiguous way and therefore should be avoided altogether. One of the examples he cites is the situation were a duration is experienced as longer than a standard. "One would say that it is overestimated when using an estimation method (5 clock seconds are estimated as 6 seconds), and underestimated when using production (5 clock seconds are produced when six – subjective – seconds are requested)" (Eisler, 1996, pp. 66). He favours using a precise description of the relationship. Although it is acknowledged that this is a valid concern for duration estimation research, it is argued that in the present context the terms over and underestimation are appropriate. There are a number of reasons for this. Firstly, all research carried out in this thesis concerns one type of duration estimation (to-be-completed tasks) using one type of reporting method (written estimates of required – unprompted temporal scale - clock time), indicating that it is clear what the terms mean. Secondly, and most importantly, unlike much of the literature concerning duration estimation, the present research is focused on 'real-world' duration estimates. Specifically, it is concerned with furthering our understanding of how people estimate the duration of to-be-completed tasks for scheduling purposes as part of their time management strategies. In this context over and underestimation have real and clearly opposing non-ambiguous consequences – completing a task early and having 'time on your hands', or not having enough time to complete the task.

2.3 Individual differences in respect to time estimation ability

Developmental differences in time estimation ability

Cognitive time skills are often considered developmental in nature (Hayes-Roth, 1980; McCormack, Brown, Maylor, Darby, & Green, 1999). Given that duration estimates are required for many, if not most, everyday situations it is important that research is focused on how this process develops. For example, in order for a child to be able to cross a road effectively he or she is required to make many duration estimates (see Hancock & Manser, 1997, for a number of other examples).

There are many other situations where an understanding of the developmental status of duration estimation is imperative. For example, this type of information is required when deciding how much weight to place on a child's duration estimation in courtroom eyewitness testimony (Block et al., 1999). Overall, as predicted by a reconstructive model (Burt, 1992, 1993; Burt & Kemp, 1991, 1994) it appears that children between one to five years gradually move from knowledge about duration of events or activities, which are acquired through specific personal experiences, to abstract knowledge allowing them to cognise about the temporal parameters of a variety of situations (Droit, 1998).

Reviews of early research conducted by Friedman (1978) and Goldstone and Goldfarb (1966) reached the conclusion that in broad terms younger children tend to overestimate duration more than older children, however very little in the way of a systematic understanding of the processes underlying these differences was provided.

There have been a number of studies that have addressed developmental changes in very short duration estimation accuracy. For example, McCormack et al. (1999) undertook a developmental study of duration estimation within the scalar timing framework. Using both generalisation tasks (participants were required to compare a stimulus duration with a previously presented stimulus duration) and bisection tasks (participants were presented with two – one short and one long – standard stimulus durations, then required to decide whether future stimuli were most similar to the long or short 'standard stimuli') they reported significant developmental differences on both types of tasks. Specifically, older adults and children were less accurate than young adults. However as acknowledged by the authors, this study addresses developmental changes in timing behaviour of very short (e.g., milliseconds) unfilled intervals. For longer time intervals it is more likely that cognitive processes will contribute to developmental changes (Block et al., 1999).

A recent meta-analysis by Block, Zakay & Hancock (1999) provides an excellent overview of developmental changes in prospective time estimation. Utilising 20 studies, their analyses suggest that children, when compared to older participants, make larger verbal estimates, similar productions, and shorter reproductions of duration. In addition, children's duration estimates tend to exhibit greater inter-individual variability than their older counterparts. The trend towards less inter-individual variability continued from adolescent through to adult participants. Block et.al. (1999) discuss these findings in light of both physiological and cognitive hypotheses of duration estimation. They conclude that the findings can be explained in terms of their attentional-gate model (discussed earlier in this chapter), and go on to suggest that the main reasons for these differences are that children may not have yet learned the verbal labels for duration units (during verbal estimates), and that they are more impatient during relatively empty durations (using the method of reproduction).

Additionally, it has been noted that children with emotional and behavioural disorders including ADHD often have problems planning to-be-completed tasks, which has been attributed to poor duration estimation skills (Barkley, 1990; Grskovic, Zentall, & Stormont-Spurgin, 1995; Nelson, Smith, Dodd, & Gilbert, 1991). These deficits are evident using both prospective (e.g., Bruno, Johnson, & Simon, 1988; Walker, 1982; White, Barratt, & Adams, 1979) and retrospective paradigms (e.g., Dodd, Griswold, Smith, & Burd, 1985; Francis, 1988; Goldman & Everett, 1985; Nelson et al., 1991). However, it is worth noting that none of the above retrospective studies controlled for IQ (see later discussion of the relationship between IQ and duration estimation accuracy).

Gender Differences

A commonly reported finding from early research was that women tended to overestimate durations to a greater extent than men (e.g., Axel, 1924; Gulliksen, 1927; MacDougall, 1904; Yerkes & Urban, 1906). However, later studies generally found no such differences (e.g., Baldwin, Thor, & Wright, 1966; Eson & Kafka, 1952; Gilliland & Humphreys, 1943; Harton, 1939; Loehlin, 1959). As such, some researchers suggested that this change in duration estimation accuracy reflects socio-cultural changes in sex-role stereotypes. Gilliland, Hofeld, and Eckstrand (1946) concluded that "it seems likely that the modern woman is called upon to make time estimates as often as men. Since time perceptions may be primarily dependent upon learning the sexes probably do not differ in ability to estimate time" (p. 168). Similarly, Goldstone (1968) concluded that "the stereotype of the female who is never on time is more consistent with the older findings of reduced accuracy which has not been demonstrated in the laboratory in recent years" (p.214).

More recently, proponents of a gender difference in respect to duration estimation suggest that this variation reflects differences in memory processes rather than socio-cultural influences (e.g., Halpern, 1992; Rammsayer, 1998). This view is backed up by the fact that sex differences are sometimes found using the method of reproduction, which presumably is not reliant on socially learned time units (Rammsayer, 1998). In addition, it has been suggested that men appear to be more proficient at representing information in memory (Halpern, 1992), which may result in women being relatively less efficient at representing a cognitive representation of temporal information (Rammsayer, 1998).

However, it needs to be made clear that while a number of studies have addressed gender, their findings are often ambiguous or conflicting and overall difficult to summarise or provide a definitive viewpoint. For example, while a number of studies using the verbal estimation method have found support for the view that women tend to overestimate duration significantly more than males (e.g., Adkins, 1972; Hornstein & Rotter, 1969), many more studies report no significant differences (e.g., Baldwin et al., 1966; Carlson & Feinberg, 1970; Delay & Richardson, 1981; Geer, Platt, & Singer, 1964; Getsinger, 1974; Hawkins & Meyer, 1965; Kirkcaldy, 1984; Roeckelein, 1972; Smith, 1969).

The typical cited reasons for conflicting gender difference results are similar to those cited for other conflicting duration estimation results – mainly, the inconsistent use of the terms 'overestimation' and 'underestimation' (Eisler, 1996; Hancock et al., 1994; Wahl & Sieg, 1980), and specific idiosyncrasies of the duration estimation method used (Block, 1989; Zakay, 1990). However, not controlling for other potentially important moderating variables, such as personality (Davidson & House, 1978; Kirkcaldy, 1984; Rammsayer & Rammstedt, 2000), IQ or level of education (Doob, 1971; Grskovic et al., 1995; McNutt & Melvin, 1968), or age (Nichelli, Venneri, Molinari, Tavani, & Grafman, 1993; Somoza & Parra, 1995), may also be adding to the confusion.

However, it needs to be reiterated that most of the above studies involve very short duration estimates using the prospective paradigm. In respect to the present focus, the picture appears to be somewhat clearer. Significant gender differences have not been reported in studies addressing pure retrospective duration estimates, or studies addressing the duration estimation of to-be-completed tasks (expected durations) for objective durations in the range of minutes (e.g., Boltz, 1998c; Boltz et al., 1998; Burt, 1999; Burt & Forsyth, 1999; Burt & Kemp, 1994; Forsyth, 1998; Francis-Smythe & Robertson, 1999; Hayes-Roth, 1980; Josephs & Hahn, 1995), therefore gender is not deemed to be a important moderating variable in the experiments conducted as part of this thesis.

Duration estimation and IQ

A number of studies have reported an association between IQ and duration estimation accuracy. For instance, a study by Grskovic, Zentall, and Stormont-

Spurgin (1995) that looked at retrospective duration estimation and planning abilities of students with and without mild disabilities, suggested that significant differences found between these groups with respect to their duration estimation accuracy could be accounted for by variations in IQ. Another interesting finding in this study was that students who were less accurate at estimating how long daily tasks had taken (retrospective) were more likely to make use of notes and lists to help organise their day (even after the effects of IQ were controlled for). Additionally, children with a higher IQ were more likely to plan ahead for important activities. IQ is 'controlled' for in the experiments conducted as part of this thesis through use of random assignment to experimental groups and/or where feasible within participant design.

Cultural differences in duration estimation

Intercultural differences concerning attitudes and belief systems associated with time have a long history in the sociology and anthropology literatures (see Whorf, 1956). It is clear that an individual's temporal reasoning needs to be approached in relation to the collective time perspective of their society or culture (Whorf, 1956). Although there is relatively little research conducted addressing cultural differences in respect to duration estimation per se, there is a body of research that suggests there are cultural differences in respect to duration estimation processing and accuracy (e.g., Akbar, 1991; Hill & Stuckey, 1992; Nobles, 1991; Rubin & Belgrave, 1999). It is suggested that any differences that occur are due to variations in how different cultures conceptualise time. Whereas a Eurocentric world view emphasises the future, an Afrocentric view sees time as being flexible with an orientation toward the past and the present – time is seen as being 'very elastic'

(Akbar, 1991). Similarly, Hill and Stuckey (1992) report that African American students tend to have a different factor structure of beliefs concerning time, which they suggest could result in different cognitive styles in relation to temporal processing.

Rubin and Belgrave (1999) conducted a study to look at cultural differences in the use of relative time estimates (i.e., elastic and flexible, such as 'very early') as opposed to mathematical time (i.e., a quantifiable time, such as '15 minutes early'), by asking students when they would arrive at various formal and informal situations. They found that African American students were significantly more likely to use relative time as opposed to mathematical time than European American students in formal structured situations (e.g., a job interview, or going to work). However, this difference was not evident in more informal situations (e.g., attending a movie with friends). The issue is not whether one is right or wrong, the issue is which orientation is congruent with the environment a person lives in. Jackson and Sears (1992) suggest that a time incongruent orientation (i.e. an Afrocentric orientation in an Eurocentric environment) may contribute to such negative consequences as increased stress, illness and disease morbidity. Rubin and Belgrave (1999) similarly suggest that in a European environment African Americans may be perceived negatively because of their use of relative time, and may be seen as lacking motivation or showing non-compliance to norms.

Similarly, cultures differ in their norms of what constitutes punctuality and lateness suggesting that there will be differences in duration estimation expertise and accuracy. Hall and Hall (1985, cited in Helfrich, 1996) suggest this constitutes part of what they call the 'silent language' of a culture, and go on to distinguish two types of time patterns – monochronic and polychronic. Monochronic is the norm in western 'individualistic' cultures and is characterised by exact time schedules and time pressure, whereas polychronic tends to be associated with 'collectivistic cultures' and is characterised by an allowance for ignoring fixed time schedules in favour of promoting the need for social harmony. Interestingly, from the present perspective, the 'timelessness' associated with polychronic time, which is typical in collectivistic societies (e.g., Japan), is also often evident in certain areas of western society, such as those at the higher levels of hierarchical organisations (Deutschmann, 1982, cited in Helfrich, 1996).

Another important temporal cultural difference that is likely to effect duration estimation accuracy is the social pace of life. In fact, research suggests that pace of life is the single most significant defining element of social time (Levine, 1996). There are strong cultural norms about the speed of action including talking, walking, and working pace. For example, Levine (1996) found a strong and consistent difference across cultures in the pace of life as measured by such things a walking speed, and work service speed (postal transaction). Interestingly, one of the measures used in Levine's study was the relative accuracy of bank clocks. These were found to be highly correlated with other measures of pace of life (i.e., more accurate clocks associated with faster walking and postal service requests). Similarly, an interesting study by Doob (1960) comparing urban with rural Jamaican people, reported that the increased social pace of life associated with urban living led to an enhancement of temporal awareness, but somewhat surprisingly, less precise duration estimates. Further, Helfrich (1996, pp. 114) suggests that "the amount of attention allocated to time seems to be highly susceptible to cultural influences such as social pace of life"

However, not all research suggests that duration estimation ability should vary greatly across different cultures. Hill, Block, and Buggie (2000) found in a recent cross-cultural study of black American, black African, and white American college students that although all three groups differed in their beliefs about physical and personal time, they shared similar beliefs concerning both prospective (e.g., 'time' seems to pass more quickly when you are busy) and retrospective duration (e.g., remembered duration seems longer if they are performing a single task) experiences. In addition, these groups demonstrated considerable agreement concerning the factors (e.g., 'filled' versus 'empty' duration periods & pleasant versus unpleasant tasks) that influence these duration experiences (a similar finding was reported by Block, Buggie, & Matsui, 1996, who compared Japanese, Malawin and American students' belief structures concerning time). Moreover, the three groups had similar belief structures concerning the accuracy of duration estimates, and whether experienced and remembered duration resulted from conscious and rational processes. Hill, Block, and Buggie (2000) go on to suggest that "beliefs about duration experiences may represent an etic factor that transcends cultures" (p.443). An 'etic' factor is one that transcends cultural boundaries, as opposed to an 'emic' factor which is culturally specific. In addition, the design of their study enabled them to examine whether the determinants of beliefs about time are predominately genetic or culturally derived. However, their data did not clearly favour one determinant over the other, suggesting that any simplistic explanation (either genetic or culture) will not fully explain the differences and similarities in human temporal experience (see Block et al., 1996, for a discussion on this topic).

2.4 Models of duration estimation

As Vandierendonck (1998) points out in the introduction to the recent publication '*Time and the Dynamic Control of Behavior*': "Despite all efforts, today no single theory or model of time estimation has been shown to explain all data available. So, the attempt to construct an adequate theory or model remains a challenging task" (pp.9). In order to provide explanatory breadth, a theory of duration estimation, especially for the retrospective or expected duration paradigms, needs to consider perceptual input, retention interval, the existence of general event knowledge, and the extent to which the interval or event in question can be defined as an event.

Following is a review of the main types of models that attempt to explain various types of duration estimation. There are a number of ways to categorise different models. For example, Ornstein (1969) differentiated between models using a 'sensory-process' approach (utilising a cumulative pulse mechanism), and those using a 'cognitive' approach. Similarly, Block and Zakay (1996) differentiate approaches as involving a 'timer' from those without a 'timer'.

The present discussion will begin by introducing two of the main types of internal timer models – internal clock and chronobiological models. This is followed by a brief overview of a prominent hybrid model of prospective duration estimation - Block and Zakay's (Block & Zakay, 1996; Zakay & Block, 1997) attentional-gate model. Lastly, and most importantly, due to its relevance to the present topic on expected duration estimation, the major models of retrospective duration estimation will be introduced, including Ornstein's (1969) storage size model, Poynter and Homa's (1983) change/segmentation model, Boltz's (1998c) 'structured remembering' approach, Block and Zayak's (1996) contextual-change model, and Burt and Kemp's (1991; 1994) reconstructive model.

Internal clock type models

There is a rich history of theorising about the possibility of internal 'clocks'. von Skramlik (1934, cited in Macleod & Roff, 1936) suggested that the human physiological clock is approximately 400 times less accurate than the best human-made clock. More recently a number of different models of duration estimation based on the idea of an 'internal clock' have been put forward, such as Treisman's (1963) influential model. Many of these models are based on the view that a pacemaker sends periodic impulses to an accumulator, with the perceived duration being the number of pulses stored (Church, 1984).

A prominent theory in this genre is 'Scalar timing theory'. According to Scalar timing theory, timing behaviour is based on the output of an internal clock that provides long-term memory representations that can be retrieved and compared with representations of the current temporal interval held in short-term memory (Church, 1984; Wearden, 1995). The term 'Scalar' refers to the proposed weberian property whereby the coefficient of variation remains constant over varying duration intervals (Ferrara, 1998). This type of timing theory was originally proposed to explain animal timing (Gibbon, 1977; Gibbon, Church, & Meck, 1984), however recently it has been employed to explain timing behaviour (predominately very short duration) in humans (e.g., Wearden, 1994; Weardon, 1998).

In support of these types of theories, there is some evidence to suggest that such variables as brain/body temperature and metabolism, psychoactive drugs, and arousal levels can alter perceived duration (e.g., Boltz, 1998b; Hancock, 1993; Maricq, Roberts, & Church, 1981; Wearden & Penton-Voak, 1995).

Although internal clock type models appear to be useful in the understanding of animal timing (Church, 1984) and human short duration estimates (see Wearden, 1995; Weardon, 1998), most are unable to explain why cognitive factors influence duration estimates. In addition, they tend to focus on prospective duration estimation. Block (1990) suggests that these types of models represent an oversimplified view of the complex mechanisms that underlie psychological time. De Vooght, van der Goten, and Vandierendonc (1998) also comment on the limited range of phenomena internal clock type models can account for. For example, no account can be given for retrospective duration estimates. Likewise, Lejeune and Richelle (1996), in their discussion of the Scalar model, suggest that it is both an advantage and shortcoming that it is a model of 'pure time', typically excluding such processes as attentional strategies, motivation, and linguistic transformations.

Chronobiological models

As mentioned earlier, time can only be perceived or inferred through changes, typically in our external environment. However, there are many internal changes that offer a degree of salience that can afford a person an effective frame of reference for time's passage, such as thoughts, proprioceptive feedback, and biological internal rhythms (Block, 1990). It is however unclear to what extent these potential pacemakers which underlie circadian rhythms, are involved in day-to-day duration estimation. It appears that longer duration estimates (in the order of hours) are influenced by circadian rhythms whereas shorter ones (seconds to minutes) may not be (Aschoff, 1984, 1985, 1993; Campbell, 1990). Most societies now substantially modify many of the natural cycles (e.g., shift work and 24-hour shopping), however this has not totally released humans from the constraints of these natural cycles of circadian periodicity (Lejeune & Richelle, 1996).

Research suggests that the estimation of long periods of time (hours) reveals a slight shortening of experienced duration. Specifically, there is typically a trend towards underestimating objective durations in the order of 1.1 (Campbell, 1990). For instance, participants may emerge from a 'time free' environment after 14 days and believe that only nine days have elapsed (Webb & Agnew, 1974). It is suggested that this underestimation is related to the tendency of our circadian rhythms to 'free-run' (without the aid of any external temporal cues) with periods slightly longer than 24-hours (Aschoff, 1984). Similarly, studies have also shown that subjective time slows as metabolic rate slows (e.g., Campbell, 1986, 1990).

Another interesting finding from this type of research is that the accuracy of these relatively long duration estimates appear to be moderated by the degree to which the participants' behaviour deviates from their normal daily habits (Campbell, 1990). Others have gone as far as to suggest that a 'normal' daily routine is essential for effective duration estimation (Siffre, 1964).

The attentional-gate model of prospective duration estimation

Although the cognitive and physiological components of duration estimation can be viewed separately, a number of researchers have proposed hybrid models which include both these elements. One prominent example is Block and Zakay's attentional-gate model (e.g., Block & Zakay, 1996; Zakay & Block, 1997). On the whole this model is functionally isomorphic to Block's (1992) contextual-change model of duration estimation (see, Block & Zakay, 1996). This model suggests that duration estimates are dependent on both physiological elements (e.g., arousal level) and cognitive elements (e.g. an attentional-gate). The attentional-gate is theorised to control how much temporal information is transferred to memory. This gate opens and closes depending upon how much attention is allocated to time. When the gate is open pulses from a pacemaker (the rate of which can be influenced by both general and specific arousal) are transferred to a cognitive counter. Put simply, duration estimates involve the counting of the number of accumulated pulses.

The important difference between this model and internal clock models is that it allows, and specifies the consequences of, a person dividing their attention between external events and attending to temporal factors (Block & Zakay, 1996). The model is predominately a model of prospective duration estimation, however a variant, which will be discussed later in this chapter, has been proposed to explain retrospective estimates (Block & Zakay, 1996).

With this model the accuracy of prospective duration estimates are directly related to the amount of information processing a person allocates to temporal information (i.e., how wide the attentional gate is and how long it stays open). According to this model a person requested to make a prospective estimation will divide their attention between temporal and non-temporal (stimulus) information (Zakay & Block, 1996). This view suggests that such duration estimates should be most accurate when the cognitive load or processing of presented stimuli is low because a greater amount of attention can be allocated to time and so opening the attentional gate (for example if participants are not required to respond to the presented stimulus) (Block, 1990). Research has found some support for this claim (e.g. Block, 1992). Further support was provided by Block and Zakay's (1997) meta-analysis of duration estimation studies that used the prospective paradigm. Overall they found support for the view that as the cognitive load of the target event increases the experienced duration decreases. In other words if a person is required to place greater attention on processing non-temporal information, less attention is directed to the processing of temporal information, and hence less time is experienced.

Stimulus versus contextual retrospective duration models

Models of retrospective duration estimation can also be classified as being 'stimulus-based' or 'context-based' (Block, 1985, 1986). Whereas stimulus-based hypotheses, like Ornstein's (1969) 'storage-size hypothesis' or Vroon's (1970) 'informational hypothesis', attempt to explain these duration estimates by focusing on the processing of the stimulus information presented during the time period, context-based hypotheses, like Block and Reed's (1978) 'contextual-association hypothesis' or Boltz's (1992) 'structured remembering approach', assume that these estimates involve more than just processing stimulus events. As Block (1986) puts it "... aspects of the cognitive context that is supplied by a person as events occur are assumed to be encoded and retrieved as an integral part of the experiencing and remembering of the events" (p. 105). This is an important observation as Block (1986) demonstrates that stimulus type models are unable to explain the 'richness' of retrospective duration estimation findings.

For example, a number of studies have not found a clear relationship between degree of 'memory' for an event and duration estimation accuracy (Block, 1986; Burt, 1999). In addition, most stimulus-based hypotheses cannot explain the common finding of positive time order effects (Block, 1982, 1986; Block & Reed, 1978). A positive time order effect is, all things being equal (or controlled through counterbalancing), being presented with two events of objectively equivalent durations, and judging the first to be longer than the second. Contextual type theories are able to explain this effect by assuming that cognitive context changes more rapidly at the start of a new experience, such as being in an experiment which results in more contextual 'change' at the start of the experience, therefore the first interval will be judged as longer (Block, 1986). Support for this type of reasoning comes from studies that show that a time order effect can be eliminated by such things as providing a different environmental context for each event (Block, 1982) or by providing a similar control event between the two to-be-estimated events (Block, 1986).

Models of retrospective duration estimation

Most models of retrospective duration estimation assume that "duration is a cognitive construction which is influenced mainly by attention and memory processes" (Block et al., 1999, pp. 185). Variants focus on factors such as attention, memory storage, and memory change (see Block, 1990, for a review).

During retrospective duration estimates it is often presumed that no, or very little, temporal information can be retrieved from memory. In line with this theorising, retrospective duration estimation is presumed to be directly related to the coding and retrieval of non-temporal information (Block, 1992). This is likely to include the remembered number of changes in cognitive context. Specifically, accuracy of these types of duration estimates are directly related to the amount of stored and retrievable information, remembered changes, contextual changes, or segmentation of the duration (Block & Reed, 1978; Fraisse, 1963; Ornstein, 1969; Poynter, 1989; Vroon, 1970). These models can all be classed as 'change models', which assume that duration estimation is based on the amount of change experienced during the target duration. As Poynter (1989) suggests "change is the psychological index of time passage" (p. 307).

For example, Ornstein (1969) proposed that the more information stored during the interval to be estimated, the longer the duration will be recalled – the 'storage size' metaphor. Subjective duration depends on the 'size' of the information stored in memory - the greater the storage size the longer the estimate. Therefore when information is numerous or complex in the environment (and that information is stored in memory), the subjective duration is longer.

A number of empirical studies have found support for the storage size model (e.g., Gray, 1982; Underwood, 1975); although there are others who question it (e.g., Block, 1986; Burt, 1992, 1999; Burt & Kemp, 1991). For example, Burt (1999) had participants produce a narrative describing a recently viewed video of a robbery, and also retrospectively estimate its duration. He found no significant correlation between estimated duration of the robbery and the number of words used to describe the event (storage size). Similarly, evidence to question the storage size hypothesis was provided by Block (1986) who demonstrated that although an internal-imagery task (for example a task requiring a person to navigate around an imaginary room in their 'mind') was remembered as being longer than a environmental-imagery task (a task involving an actual room) of equivalent objective duration, the environmental-imagery task resulted in significantly better free-recall than the internal-imagery task – the opposite result to that predicted by the storage size hypothesis.

Alternatively, Poynter (1983; 1989), and Poynter and Homa (1983) proposed a change/segmentation model of retrospective duration estimation. Poynter suggests that "if the interval is filled with sensory stimuli, then the estimate will be based primarily on the number and discreteness of the sensory changes remembered from the interval" (Poynter, 1989, p.312). One of the more pertinent aspects of this model is that it recognises the importance of discreteness and memorability of events in providing an effective framework for storage and retrieval of information on which to base the duration estimation (Poynter, 1983) - the more salient and discrete an event, the easier the event can be 'chunked' for efficient encoding and retrieval. Poynter (1989) suggests that one form of salience which greatly assists us in making retrospective duration estimates is that, because of the unidirectionality of time (at least we perceive it as such, see Leggett, 1978; Stenger, 2000, for a discussion on this topic), we have learned the temporal relations of many natural event sequences. For example, it is easy for us to temporally organise a sequence of photographs depicting the cutting down of a tree and the making of furniture from the resulting wood.

At the same time, like other models of retrospective duration estimation, the change/segmentation model acknowledges the importance of observer variables, such as attentional demands and capacity, and motivation in influencing remembered duration. Poynter (1989) suggests that the model's strength is that it is relatively parsimonious in that it suggests we judge duration in much the same way without clocks as we do with clocks, "by accounting for the 'nontemporal' change between delimiting events" (p. 329).

In a similar vein is Boltz's (1998c) 'structured remembering' approach. In common with Poynter's change/segmentation model, the 'structured remembering approach' suggests that "the remembering of event durations is dependent upon the inherent organisation of information within an event's time span" (Boltz, 1998b, p. 113). It is argued that incoherent events lack structural predictability, which disrupts both attending and remembering processes (Boltz, 1998b). Using a retrospective paradigm, Boltz (1992; 1994) required participants to perform a series of perceptual rating tasks with tonal sequences, or environmental sounds, which varied in their degree of structural predictability and number of presentations. Overall these studies found that durations for coherent events were well remembered, which also showed a learning effect in relation to the number of presentations. However, incoherent events were poorly remembered and showed no learning effect.

It was suggested by Boltz (1992) that events which are invariant over time (highly predictable), have inherent structures which influence attention, expectancy, and memory, thus allowing for the recapitulation and accurate duration estimation of these events (individuals are thought to incidentally learn the inherent duration). This viewpoint is in tune with current theorising in the area of autobiographical memory. For example, Neisser (1986) suggests that nested structure is important in the storage and retrieval of autobiographical memories. Payne (1993) also highlights the importance of structure and coherence during prospective remembering – remembering to do things.

Although, Block and Zakay's (Block & Zakay, 1996; Zakay & Block, 1997) attentional-gate (contextual change) model discussed above is predominately a model of prospective duration estimation, a variant has been proposed to explain retrospective estimates. In common with most theorising concerning retrospective duration estimates, this model suggests that "judgements do not depend so much on retrieval of temporal contextual information as on retrieval of other kinds of contextual information" (Block & Zakay, 1996, p.187). Based on accumulated research (e.g., Block, 1986), this model represents a continual development and refinement of Block and Reed's (Block & Reed, 1978) original contextual explanation. The contextual information is presumed to be encoded with more general event information, and incorporates environmental, emotional, and process information. Overall, the duration estimation is a function of the amount of contextual changes that can be retrieved from memory (Block, 1992).

Figure 1 depicts Block and Zakay's (1996) contextual change model for retrospective estimates. Most of the focus is on associations formed (mostly automatically) between the context generator (supplier of context information) and event information (stored in long-term episodic memory). This model allows for the fact that on rare occasions the person may attend to temporal factors at the time of encoding. In these cases the 'gate' will be opened allowing the context recorder to hold information concerning contextual changes, and associate this information with concurrent events. This information is also sent to a long-term reference memory which "holds information about the average amount of unique contextual information stored during durations of various lengths" (Block & Zakay, 1996, p. 187) – information concerning the translation of contextual information into temporal duration estimates. Finally, the actual duration estimation involves a context comparison, which incorporates information held in the long-term episodic memory and long-term reference memory.

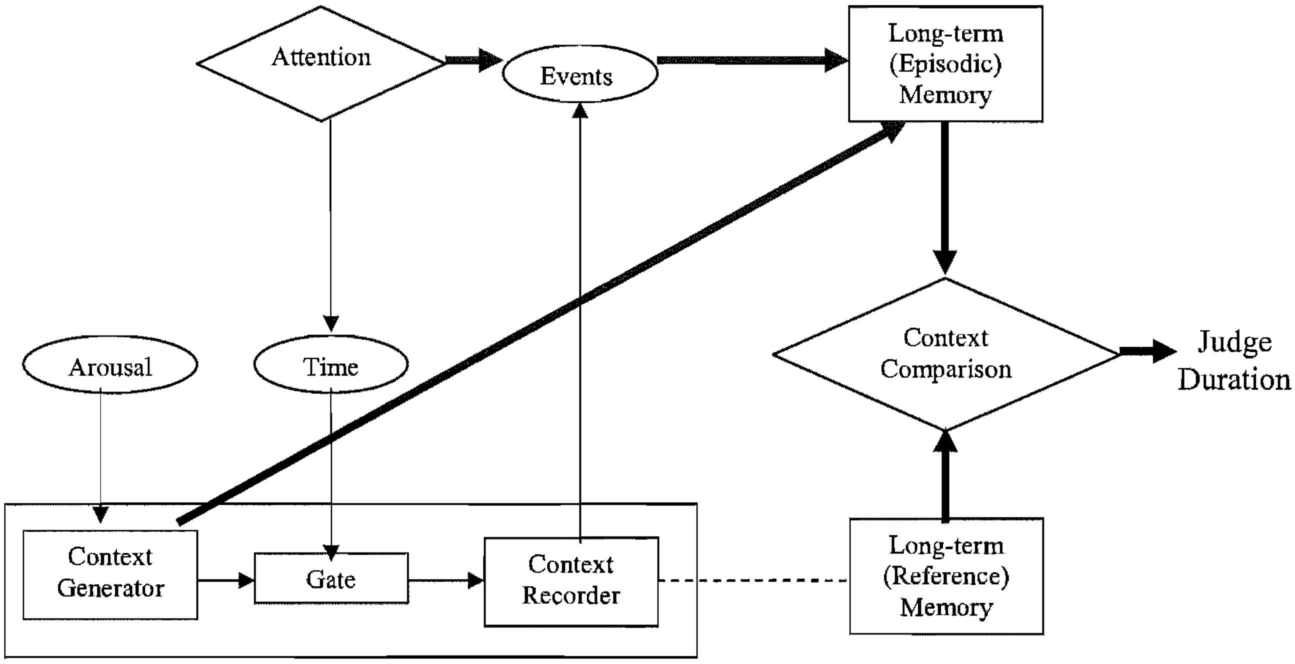

Figure 1. Block and Zayak's (1996) contextual-change model of retrospective duration judgement.

Finally, Burt and Kemp (1991; 1994), and Burt (1992; 1993) have put forward a reconstructive model to help explain retrospective duration estimation. Burt (1992) suggests that "reconstructing event duration may involve the use of (1) general event knowledge already stored in memory, (2) information provided in the event description, and (3) memory of the event." (p. 128). This model suggests that people rely heavily on reconstructing the event based on general knowledge gained through repeated exposure/experience to that 'category' of event (Burt, 1992). When a person possesses specific event knowledge they are able to use this knowledge to adjust their reconstructed estimates either upwards or downwards, depending on the direction and degree of atypicality. It is suggested that temporal information may be encoded as part of this general event knowledge. Although most other theorising focuses on the effects of perceptual input during the event, this model highlights the influence of general knowledge (concerning the events typical duration) has on the duration estimation (Burt, 1993).

It should be noted that this model was developed using events longer than one day. Although Burt (1993) suggests that caution is needed in applying this model to shorter events (i.e., hours or minutes rather than days) he sees no obvious reason why the process should be different for these shorter events.

Burt and Kemp (1991) found no evidence to support Ornstein's (1969) implied relationship between retention interval and estimated duration, however they did find evidence that people reconstruct public event duration by using general knowledge. Participants required to provide duration estimates of specific public events (e.g., the 1985 hijacking of TWA Flight 847) gave similar estimates to those required to provide estimates for general descriptions of such events (e.g., an aeroplane hijack). Overall people tended to underestimate these durations. Burt and Kemp (1991) suggest that this may have been because most of the specific events used in this study were atypically long. In addition, they found that event knowledge (measured on a 7-point rating scale) did increase estimation accuracy.

Furthermore, Burt (1992) examined participants' capacity to recall the duration of autobiographical events recorded in personal diaries. No support was found for Ornstein's storage size model in that the duration estimates were not proportional to event knowledge and there were no clear time order effects. He also found that estimates were generally accurate, even when the events could not be remembered, suggesting that participants reconstructed the event duration. Support for the view that this reconstruction is based on general event knowledge was provided by a second study in which participants provided with general descriptions of specific events used in the first study, provided very similar duration estimates.

More recently Burt, Kemp, and Conway (2001) have retested many of the participants involved in Burt's (1992) study. This follow-up study gathered data concerning these participants' capacity to recall autobiographical duration information 10 years on. Overall, they found these estimates to be very similar to the earlier estimates (the estimates replicated all of the patterns outlined above). This follow-up data provides robust support for the reconstructive model of duration estimation.

Chapter 3

Time management

Before introducing my model of expected duration, a paradigm in which this type of cognitive task is regularly used will be introduced - time management. It is important that this topic is introduced at this point as it provides an excellent real-world situation in which to develop and test the 'expected duration model'.

Time management is an ideal area in which to investigate expected duration estimation. One of the primary tasks one has to undertake in order to be able to manage their time is that of estimating how long future tasks are going to take so that their completion can be 'scheduled'. In light of this fact this chapter introduces the reader to the concept of time management and the function that expected duration estimation plays within time management.

Specifically this chapter introduces the concept of time management including the measurement of this construct, its potential bearing on an individual's psychological and physical health, and the utility of time management training. The second half of the chapter provides a discussion of the role and importance of scheduling, and more specifically estimating the duration of to-be-completed tasks, for effective time management. It will be argued that accurate duration estimates of to-be-completed tasks are desirable from both a time management/psychological well-being perspective and a pure efficiency perspective (further reinforcing the need for a comprehensive understanding of the expected duration process).

3.1 The concept of time management

Time management is a broad term used by lay and business people, and academics alike. But what do we mean by time management? Surely one cannot truly manage time?

Time is arguably our most valuable resource, being directly related to all forms of human activity. However, unlike many other resources it cannot be stored for later use (Sharp, 1981). Given that time must be spent (in one way or another), the central issue becomes how we can use it most effectively. Strategies and techniques that purport to enhance the effective use of time are typically discussed under the heading of time management (Drucker, 1966). Although the accepted term is 'time management', 'self management' better represents the construct. Time management concerns the processes and outcomes of strategies that people use to manage themselves in relation to time rather than the management of time per se. That said, the term time management is widely used and understood so will be adopted in this thesis.

Use of time is constrained by strong cultural dictates (see section 2.3), which determine how one's day and night, week, and life should be organised. It is widely recognised that the standardisation of time measurement throughout western society, facilitated as clocks became widespread, went hand-in-hand with the idea of 'time thrift' proclaimed by educators, moralists, and employers (Dohrn-van Rossum, 1996). Thompson (1967) suggests that western mass consciousness has gradually absorbed an ethic that one's time should be spent in clearly purposive action. Generally, this is still held to mean being engaged in, preparing for, or supporting those in paid employment. Those whose life has no such purpose, notably the unemployed (but also the sick and the retired), tend to be condemned and/or accorded low social status (Thompson, 1967). A quote from a man who had recently been made redundant demonstrates the connection between time and employment – "Time doesn't matter now as much as it used to….there's so much of it" (UK, 1980s, cited in Fryer & McKenna, 1987).

The need for some kind of regularity and order is fundamental to humankind (Thompson, 1967). In more 'traditional' societies, structure is provided through various kinds of ritual (often religious) activity. In the western world this need has come to be associated with the desire for a 40-hour working week (depending upon the country), and a working life often spanning up to 50 years. In fitting with this viewpoint, many people comment that if they earned the same pay for working only 20 hours instead of 40 they would seek a second job (Bostyn & Wight, 1987). Likewise, Jahoha (1982) argues that "time experiences are structured in industrialised societies through the ubiquity of employment conditions" (p. 59). Formal employment provides a basic grid against which a person's life is charted out.

It is important to re-emphasise that temporal orientations and reasoning about time vary greatly across cultures (Block et al., 1996; Rubin & Belgrave, 1999) and also to a lesser extent between different organisations within the same culture (Hassard, 1991; Schriber & Gutek, 1987). In relation to these findings, care must be taken when applying the predominately western model of time management to other cultures (Mpofu, D'Amico, & Cleghorn, 1996) (see section 2.3).

3.2 Defining the time management construct

Presently, there is disagreement in the literature as to whether time management behaviours reflect a set of learned behaviours or some dispositional aspect of an individual's personality (Landy, Rastegary, Thayer, & Colvin, 1991; Macan, 1994). Fontana (1993) suggests that effective time management comprises of a multitude of learned behaviours. In support of this view research demonstrates that training in time management techniques can improve an individual's time management ability (e.g., Hall & Hursch, 1982; Hanel, Martin, & Koop, 1983; King, Winett, & Lovett, 1986). Other researchers argue that effective time management is a result of various dispositional aspects of an individual's personality. For example, Calabresi and Cohen (1968) and Wessman (1973) propose that attitudes towards time reflect a basic feature of an individual's personality. More recently, Shahani, Weiner and Streit (1993) conducted a longitudinal study that revealed that university students' self-reported use of time management behaviours remained relatively stable under varying levels of academic pressure, providing some support for the dispositional nature of the time management construct.

Whether effective time management behaviours reflect a set of learned responses or some dispositional aspect of an individual's personality, most researchers agree that it involves particular key processes, such as identifying goals and objectives, ranking them in regard to importance or priority, and then allocating time and resources accordingly (see Landy et al., 1991; Macan, Shahani, Dipboye, & Phillips, 1990). Macan's (1994) process model, shown in Figure 2, identifies three main factors which contribute to effective time management: setting goals and priorities; mechanics (including making lists and task time estimation); and preference for organisation. These three factors all contribute to a person's perceived control of time. The important part of this model is that it is this perceived control of time (as opposed to some objective time usage type of measure) that results in the positive outcomes cited on the right-hand side of the figure below.

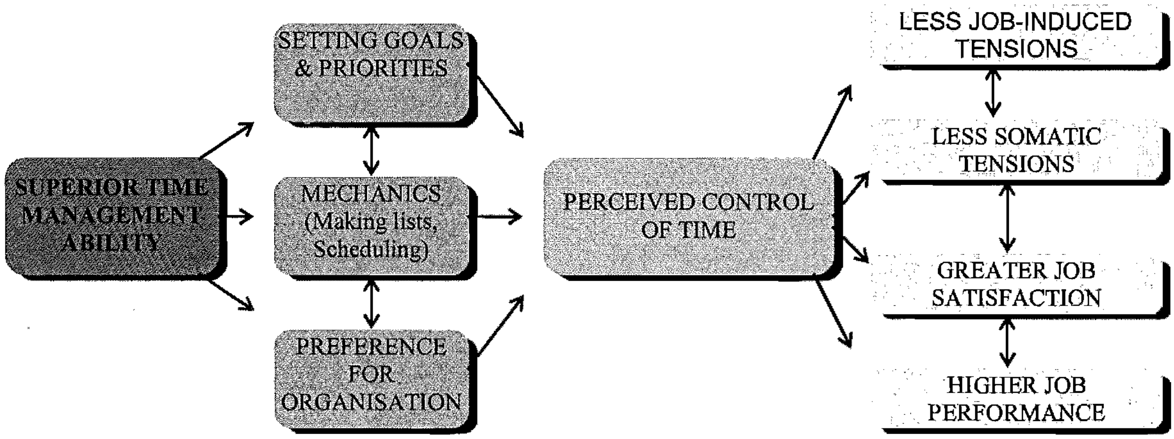

Figure 2. Macan's (1994) process model of time management.

3.3 Measuring the time management construct

The capacity to systematically research and contribute to our understanding of time management is ultimately linked to the ability to develop and utilise psychometrically sound measures to represent this multidimensional concept accurately. In addition, in light of the negative effects of poor time management discussed in section 3.4 below, it appears prudent, where effective time management is identified as an essential competency, to include a measure of time management ability as part of employee selection packages. This inclusion is of particular importance given the probable dispositional component of the time management construct. If effective time management is essential for a given occupation, it will be more efficacious to recruit superior time managers than try to overcome a predisposition for poor time management through substantial, and expensive, training. If effective time management is a robust aspect of an individual's personality, time management training will have only a limited effect on behaviour. Again, selection of superior time managers is reliant on having a reliable and valid measure of time management ability.

A number of published scales exist which purport to measure the time management construct - The Time Structure Questionnaire (Bond & Feather, 1988), The Time Management Behaviour Scale (Macan et al., 1990), The Britton and Tesser Time Management Instrument (Britton & Glynn, 1989), The Temporal Experience Questionnaire (Wessman, 1973), and The Time Attitudes Questionnaire (Calabresi & Cohen, 1968).

The Time Structure Questionnaire (Bond & Feather, 1988) and The Time Management Behaviour Scale (Macan et al., 1990) are two of the most popular scales. The Time Structure Questionnaire (TSQ) (Bond & Feather, 1988) contains 26 items that measure the degree to which participants perceive their use of time as structured and purposive. Each item is rated using a one to seven scale. Six scores are calculated from the TSQ ratings, a summed TSQ score which ranges from 26 to 182 (higher scores indicate more time structure), and five factor scores - Purpose, Routine, Orientation, Organisation and Persistence, respectively. Coefficient alphas in the vicinity of .73 - .75 have been reported for both the summed TSQ score and the factor scores (e.g., Shahani et al., 1993).

During earlier validation and development of the scale, Feather & Bond (1983) investigated time structure in a sample of employed and unemployed university graduates using a number of self-assessment scales, including a 17-item version of the TSQ. They reported that the unemployed group were less organised and less purposeful in their use of time, and reported higher levels of depression and lower self-esteem than the employed group. In addition, they found that the more structured and purposeful use of time, as indexed by the TSQ, was positively related to global self-esteem and negatively related to depressive symptoms for both the employed and unemployed samples.

However, studies by Burt and Forsyth (1999), and Forsyth (1998) suggest that the TSQ may not predict actual time management ability. Both these studies used task duration estimation accuracy as their performance measure. Both studies found no meaningful relationship between task duration estimation accuracy and TSQ scores. Although superior time management involves much more than estimating the duration of future to-be-done tasks, it is one of the essential components of good time management.

The Time Management Behaviour scale (TMBS) was developed by Macan et al. (1990) to assess behaviours they felt were critical to successful time management. The original instrument contained 46 (reduced to 38, then 34 by Macan) items, rated on a scale from seldom true (0) to very often true (4). Negatively worded items are reverse scored so that upper ends of the scale indicate more frequent use of productive time management behaviours. The scale is made up of four factors: setting goals and priorities (TMBS 1); planning and scheduling (TMBS 2); perceived control of time

(TMBS 3); and preference for organisation (TMBS 4). More recently Adams and Jex (1997) carried out a confirmatory factor analysis, which provided further support of the factor structure proposed in the TMBS. Their study suggested that the instrument could be reduced to 28 items without a reduction in psychometric properties.

Additionally, Krause's (1999) recently developed 'Australian Time Organisation and Management Scale (ATOMS)' looks promising. The scale, which is yet to be published, consists of 62 items measuring both time management behaviours and attitudes. Krause (1999) suggests these will provide clarification of the concept of time management, with specific focus on its relationship to personality dimensions. The scale is comprised of six factors: purposivism; time facilitation; mechanics; temporal perspective; spontaneity; and effective organisation. It appears to be psychometrically sound (Krause, 1999).

3.4 The effects of poor time management

The importance of effective time management for psychological well-being is widely reported. The literature contains substantial longitudinal and cross-sectional studies which suggest that whether a person is able to occupy their time in a purposive and structured way is highly correlated to psychological well-being (e.g., Banks & Jackson, 1982; Feather, 1990; Hepworth, 1980; Kilpatrick & Trew, 1985; Warr & Payne, 1983). Conversely, Hawkins (1997) suggests that adults tend to view time and its management as their greatest stressor.

Specifically, poor time management skills have been associated with high levels of stress (e.g., Goldberger & Breznitz, 1982; Macan et al., 1990; McLaughlin, Cormier, & Cormier, 1988; Schuler, 1979; Tanner & Atkins, 1990; Wratcher & Jones, 1986), low performance/productivity (e.g., Britton & Tesser, 1991; Kleijn, Van der Ploeg, & Topman, 1994; Macan et al., 1990; Wratcher & Jones, 1986), feelings of purposelessness, neuroticism, hopelessness and depression (Bond & Feather, 1988; Feather & Bond, 1983), and less effective group and individual decision making (Benson & Beach, 1996; Kelly, Jackson, & Hutson-Comeaux, 1997). Similarly, studies by Owen (1991) and Steinberg (1996) suggest that whether a person sees him or herself as being an effective time manager or not is connected with whether they perceive their time as being 'filled' or 'wasted'. In the business world filled time most often equates to productive time on-the-job.

In student populations effective time management has been shown to be an important facilitator of academic performance (Battle, Grant, & Heggoy, 1995; Huang & Waxman, 1995; Sweidel, 1996). Students with effective time management skills also have an ability to cope with stress (Tracey & Corlett, 1995), and have higher levels of motivation (Senecal, Koestner, & Vallerand, 1995). Similarly, effective time management has been shown to be an important moderator of student time usage (Bruno, 1995; Etcheverry, Clifton, & Roberts, 1993), and time allocation choices (Kobasigawa & Metcalf-Haggert, 1993; Shaw, Caldwell, & Kleiber, 1996). Conversely, ineffective time management has been associated with problem behaviour (also see developmental differences in section 2.3) (Ansari & Chowdhri, 1988; McKee, 1996; Thombs, 1995). Interestingly, Shaw, Caldwell, and Kleiber (1996) suggest that female students may suffer greater levels of time stress than their male counterparts (also see section 2.3).

Jacobs (1992) vividly demonstrates the potential monetary costs of poor time management. If an organisation employs 1000 people who earn on average $30,000 per annum, and if all these employees waste only 1 minute per day through poor time management, the organisation has spent $62,500 on unproductive time over a year. Incredibly, this amount is equivalent to having two workers absent for the whole year! However, the association between performance and time management is probably often less direct than alluded to by Jacobs (1992). For instance, Barling, Kelloway and Cheung (1996) suggest that a number of other variables – notably motivation – may moderate the association between effective time management and performance. Likewise, Burt and Forsyth (2001) report an association between organisational climate and effective time management. However, it is important to note that there are likely to be both direct influences to productivity through effective time management (see, Macan, 1994) and indirect ones through elevating the negative elements mentioned above, such as improved motivation, more effective decision making, and less purposelessness.

In general, research suggests that employees who are good at managing their time are generally more successful than those who are poor at doing so (Kotter, 1982; Mackenzie, 1990).

3.5 Time management training

In light of the importance of effective time management, it is not surprising that organisations spend a substantial amount of time and effort trying to improve employees' time management skills (Lakein, 1991; Maher, 1990). Strategies include purchasing expensive scheduling software and daily planners, running in-house time management seminars, and sending employees to time management workshops

(Maher, 1990). The latter, aimed at reducing levels of stress and improving employee productivity, are often advocated by occupational counsellors (Schuler, 1979; Wratcher & Jones, 1986). However, despite many organisations spending a great deal of time and money on promoting effective time management behaviours, there appears to be very little in the way of measurement of actual needs or resulting behaviour changes. It is often presumed that all employees are of equal need when it comes to time management training (Hall & Hursch, 1982). Where time management training programs are evaluated, they tend to concern only employee attitudes (e.g., Hanel et al., 1983; Woolfolk & Woolfollk, 1986). It is only occasionally that an attempt is made to assess behaviour changes due to these training programs (e.g., Hall & Hursch, 1982; Orpen, 1994; Slaven & Totterdell, 1993). By not carrying out a needs analysis an organisation puts itself in an impoverished position making it difficult, if not impossible, to develop training objectives, choose appropriate training methods, or evaluate training effectiveness (Goldstein, 1993).

Although the effectiveness of time management training is often touted (e.g., Lakein, 1991; Richards, 1987; Schuler, 1979), the limited research into this area questions its true effectiveness. A number of studies have revealed that time management training can increase the amount of time participants spend on high-priority tasks (Hall & Hursch, 1982; King et al., 1986; Maher, 1986; Orpen, 1994). However, these studies do not directly address whether the time management training resulted in an increased use of time management behaviours advocated by time management consultants (e.g., Lakein, 1991; Mackenzie, 1990).

In addition, research suggests that time management training may be ineffective at reducing stress or improving performance (Bost, 1984; King et al., 1986). In general, much of the research in this area has been conducted with small sample sizes (i.e., N<5) and/or in the absence of appropriate control groups (e.g., Hall & Hursch, 1982; Maher, 1986).

To overcome some of these methodological shortcomings Macan (1996) conducted a field study that compared a variety of self-reports and supervisory performance ratings of a group of employees who had undergone time management training with a group that had not (all measures for both groups were assessed before the training and approximately five months later). Somewhat surprisingly, trained participants did not report greater use of time management behaviours, more job satisfaction, or less job-induced stress than the non-trained group. In addition, the trained group's job performance (measured by supervisor ratings) showed no significant increase five months after training.

The only positive outcome of the training in Macan's study appeared to be that the trained participants' perceptions of control over time showed an increase five months after training - where it approached the level of the non-trained group. Macan (1996) provides an interesting explanation for this outcome - "perhaps training allowed the participants to compare themselves with others, providing them with a realistic benchmark with which to evaluate their situation" (p. 234). In support of this view she highlights similar findings that have shown comparative knowledge can be helpful in alleviating some of the negative consequences associated with burnout (Maslach, 1982). Basically, Macan (1996) suggests that comparative knowledge (concerning the similar situation other people are in) about one's situation in respect to 'time pressure' results in similar positive affects as does formal time management training.

Another area that warrants attention by researchers and practitioners is the role personality plays as a moderator of time management training effectiveness. If time management is unrelated to personality type then time management training may be able to be applied undifferentiated across the population. However, this is probably not the case. For example, Williams, Verble, Price, and Layne (1995) report that time management factors were significantly related to the 'Judging' dimension of the J-P index of the Myers Briggs Type Indicator (Myers & McCaulley, 1985), suggesting that time management factors are most closely related to what Myers and Briggs (Myers & McCaulley, 1985) refer to as having a planned, orderly, and controlled way of living.

It remains to be determined what differential effect personality has on time management training. Williams et al.'s (1995) study suggests that people with a judging orientation will probably respond to time management training in a favourable way. However, this population is likely to already be 'good time managers'. As Williams et al. (1995) point out "...an individual with a perceiving orientation might really need time management training, but his or her orientation might be an impediment to profiting from that training" (p. 41).

Similarly, Shahani, Weiner, and Streit (1993) suggest that companies should be careful about "jumping on the time management bandwagon" as "it is likely that the typical 3-4 hour time management workshop will have limited efficacy in permanently changing employee time management skills" (p. 242). However, they allude to the possibility that certain factors (e.g., high motivation) may over-ride time management dispositional orientations.

3.6 Scheduling the completion of to-be-completed tasks

The scheduling of to-be-completed tasks is a ubiquitous component of 'how-to' time management books (eg. Fontana, 1993; Jacobs, 1992; Mackenzie, 1990) and the academic time management literature (e.g. Bond & Feather, 1988; Britton & Glynn, 1989; Burt & Kemp, 1994; Francis-Smythe & Robertson, 1999; Macan, 1994).

The importance of effective scheduling to managing one's time is further demonstrated by Macan's process model of time management. As can be seen in Figure 2 the 'mechanics' component, of which scheduling plays a major part, is one of the three factors that her model suggests leads to a perceived control of time. There is some empirical support for the view that those who perceive themselves as being good time managers are more accurate at estimating the expected duration of to-be-completed tasks (Francis-Smythe & Robertson, 1999). Specifically, those who perceived themselves as being in control of time, or practising effective time management behaviours, estimated expected task durations with greater accuracy than those who did not (Francis-Smythe & Robertson, 1999).

Past research concerning scheduling has addressed issues like time planners as an organisational tool (e.g., Hildreth, Macke, & Carter, 1995; Sweidel, 1996); project management scheduling (e.g., Salewski, Schirmer, & Drexi, 1997); scheduling as a cognitive activity (e.g., Garling, 1994, 1996; Paese, 1995; Payne, 1993); scheduling as a communication tool (e.g., Walleri & Stoering, 1996); planner/scheduler design (e.g., Burt & Forsyth, 1999; Kelley & Chapanis, 1982); and the costs of poor scheduling (e.g., Benson & Beach, 1996; Kelly et al., 1997; Mano, 1990).

3.7 Scheduling materials

Whether they are referred to as diaries, calendars, planners or schedulers, their usage is an important part of many people's workday, and in many professions it is a ubiquitous personal tool (Kelley & Chapanis, 1982; Payne, 1993). For example, Kelley and Chapanis (1982) report that all 23 working professionals in their study used a calendar or diary on a daily basis, and all participants believed that a calendar or diary was essential to conduct their business. Diaries, or schedulers, are used in a variety of ways depending on personal preference. Typically they enable one to manage one's time, and other important information and facts. Benefits such as 'being able to use your head for more important things', and stress reduction are widely proclaimed (e.g., Burger, 1974; Hegarty, 1976; Mackenzie, 1990). However, surprisingly little research has been conducted on these tools.

One important issue of scheduling use is its design and format. However, a recent literature search returned very few studies dealing directly with schedule design and format (see Kelley & Chapanis, 1982; Payne, 1993; Burt & Forsyth, 1998). At a most basic level are the mass-produced 'diaries', which provide basic facilities for scheduling appointments, and filing personal information and notes. These devices also provide varying degrees of calendar information and other useful facts (e.g., currency conversions). Typically, these diaries are rather generic and offer no formal personal customisation. At the other end of the continuum is the range of digital schedulers that are custom-designed to meet the user's particular requirements.

Marketers of scheduling devices and business consultants (e.g., Bickers, 1997; Fienberg, 1995) often proclaim the advantages of digital schedules over paper ones. Advantages include superior information capacity, reusability, smaller size, superior 'look-up' capabilities, ease of archiving, and increased functionality (i.e., clocks and alarms), and greater information security. In a similar vein, Kelley and Chapanis's (1982) study of scheduler usage by a variety of professions strongly supported a move towards computerisation of schedulers. More recently, Payne (1993) suggests that the reality of electronic schedulers may not be as rosy as Kelly and Chapanis (1982) prophesised. Specifically, people still tend to continue to use paper schedulers, even in highly computerised environments.

Payne (1993) undertook an analysis of scheduler use focusing on electronic versions, again finding that some form of scheduler was essential for most professionals to manage their day-to-day lives. Similar to Kelly and Chapanis (1982), Payne found that while studying a rather homogeneous sample, there was a large amount of diversity in what type of schedulers people used and how they used them. Seventy per cent of the participants used only paper schedulers and of the 30 per cent who reported using electronic versions over half of these also still relied on some form of paper scheduler.

In light of these findings Payne (1993) suggests that paper schedulers are more effective in promoting prospective remembering - remembering to do things - through the by-product of incidental browsing of existing appointments during subsequent scheduler entering. Furthermore, Payne (1993) suggests that "electronic calendars are restricted in their representational capabilities, for they do not mimic the capabilities borne by the rich typography and arbitrary graphical conventions used in paper calendars" (p. 97). Figure 3 depicts Payne's graphical representation of the general structure of this prospective remembering. This process model shows the stages from forming the intention to carrying the act out until completed. The boxes on the left represent the influence of scheduling the intention - a common but not essential prerequisite of prospective remembering. Of course entering an intention into a scheduler 'forces' it to be scheduled within a time frame. The boxes on the right-hand side of the main stages represent the possibility of being inadvertently 'reminded' ("That reminds me...") or deliberately rehearsed ("What do I have to do today?").

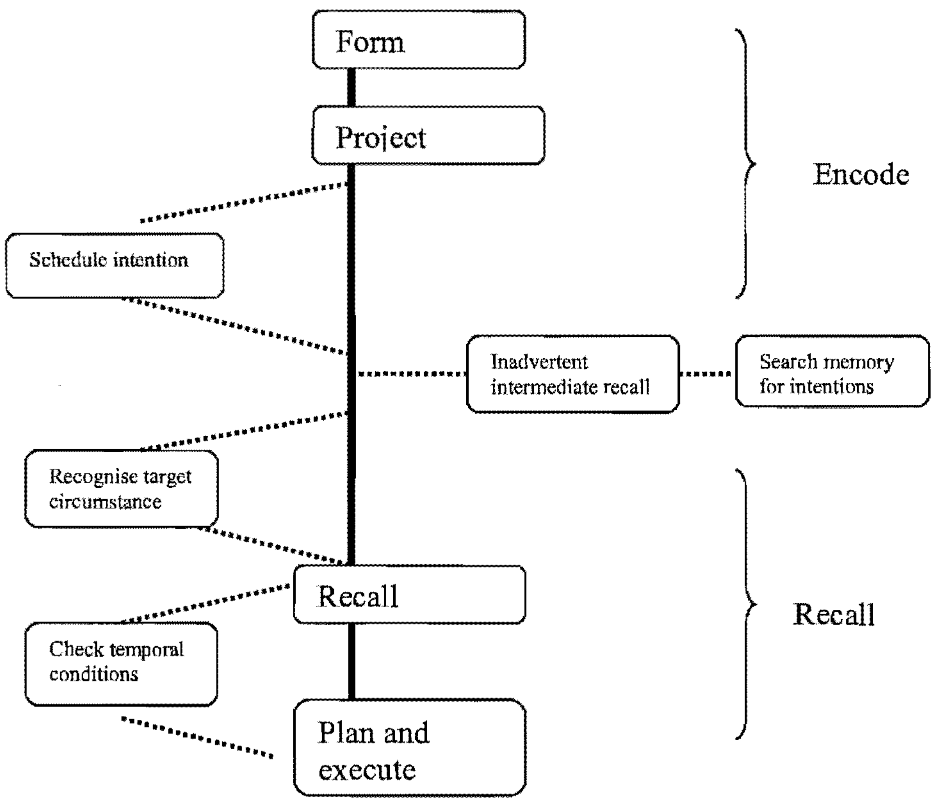

Figure 3. Payne's (1993, pp 91) graphical representation of prospective remembering. The central virtual lines enclose and join necessary stages, while other links (dashed lines) represent possible stages.

One of the interesting parts of Payne's model, is that it incorporates the view that an intention is encoded by mentally projecting it – "the imagined realization of the intention" (Payne, 1993, p.91). Payne goes on to suggest that this process will often involve elaboration, which will include "... some 'backward' imagining of precursive actions" (Payne, 1993, p. 91). Likewise planning per se may occur at the same time or be somewhat temporally removed. In addition, Payne suggests that the projection of intentions is elaborated during scheduler entry by the context of other entries and also the spatial representation of time (i.e., time is typically represented chronologically down a page and onto the next). By being forced to enter a task or appointment into a calendar 'around' other tasks/appointments one is forced to imagine a richer sequence of events – facilitating 'event reconstruction' (see expected duration estimation model, Chapter 4). These factors are more easily facilitated with the higher levels of browsability inherent within paper based calendars. It appears that the projection of new entries is made more effective by the rehearsing of existing ones, giving a form of feedback.

3.8 Duration estimation and scheduling

Of particular relevance is the duration estimation component of the scheduling process, which relatively few researchers have addressed (e.g., Buehler, Griffin, & Ross, 1994; Burt & Forsyth, 1999; Burt & Kemp, 1994; Forsyth, 1998; Francis-Smythe & Robertson, 1999; Hildreth et al., 1995; Josephs & Hahn, 1995). Task duration estimation accuracy is an important aspect of effective scheduling and so an essential component of effective time management. Estimating expected duration of a task or event, as part of a planning process, is a frequently undertaken cognitive process (Hayes-Roth, 1980). It is utilised in many common activities as diverse as feeding a baby, to building an offshore oil-drilling platform, and in some cases the planner has limited prior knowledge of time requirements. In such circumstances the planner must estimate time requirements, and the accuracy of these estimates is an important limiting factor on the quality of the plan. Most people have experience of the potential costs of inaccurate future task-duration estimation. There are ubiquitous reports of grand construction projects blowing budgets primarily through inaccurate duration estimates (see Hall, 1980). At an individual level they can range from offending a friend because you are late for a movie, to losing one's job (Mano, 1990).

The importance of being able to accurately estimate the expected duration of a task or event is reinforced by Burt and Kemp (1994) who state that "...the allocation of time is fundamental to the success or failure of one's time management activities" (p.157). As they point out, if an individual always underestimates task-time they will run out of time. Conversely, if the individual always overestimates task-time they will be left with time to spare, which may or may not be used productively (see 3.10 below for a discussion of this issue).

An early study by Burns (1957) found, somewhat intuitively, that employees tend to overestimate the time they spend on important activities related to work and to underestimate personal time. However this study had a major confound in that the measures of actual and estimated durations were both based on self reports (there were no 'objective' measurement of actual durations) meaning that caution is required in interpreting these findings. Another study by Klemmer and Snyder (1972), which used a more objective measure of actual duration (random activity sampling), found a large level of variability in the accuracy of employees' estimation of task durations –

both across employees and tasks. For instance, they found that participants typically underestimated how long they had spent in face-to-face conversation, whereas they tended to overestimate the time they spend on reading or writing.

It is also worth pointing out that accurate task duration estimates have other occupational uses beyond facilitating effective time management. From an organisational perspective, specifically during the process of job analysis, it is helpful if employees are able to accurately estimate how much time they spend on different tasks. A common way to gather information about a position/job is to ask the incumbent (Levine, Ash, Hall, & Sistrunk, 1983; Schuler, 1989). Accurate duration estimates from such self-reports are used to help define training needs, facilitate job restructuring, and establish wage and salary levels (Schuler, 1989). Additionally, collecting duration estimates of work tasks/processes over time can potentially provide valuable information concerning savings or costs resulting from the implementation of new work procedures, training, or technology (Hartley et al., 1977).

3.9 Accuracy feedback for duration estimation

Although Campbell (1990, p. 101) has pointed out that typically "time estimation is neither a well-reinforced behavior nor one for which there is much opportunity to practice" it is argued that this is not the case for duration estimation connected to the scheduling of to-be-completed tasks. As has already been noted above, on the first count there would appear to be many reinforcements connected to being able to accurately estimate the duration of a to-be-completed task. For example, a study by Robertson and Kinder (1993) demonstrated that human resource consultants believe that employees who are accurate at estimating expected duration are more effective workers. Secondly, people are continually getting practice at estimating such durations. This may range from scheduling to-be-completed-tasks using a daily scheduler or diary, or making mental notes concerning the expected duration of an up-coming task. All of these duration estimates represent practice, as the person will typically receive feedback on their estimation accuracy (whether they update relevant knowledge or not is another issue). It therefore appears that people can potentially receive feedback for accurate duration estimation for to-be-completed tasks in a work environment.

3.10 Parkinson's first law – why accurate duration estimates are important

From what has already been discussed, there are two main outcomes of inaccurate duration estimation for the scheduling of to-be-completed tasks. Firstly, if an individual always underestimates task-time they will run out of time and not be able to complete all tasks. Clearly, this is not a good situation, although some underestimation may increase productivity in specific situations (see discussion below). Conversely, if the individual always overestimates task-time they will be left with time to spare. This second situation could be viewed as an effective strategy to manage your time (Burt & Kemp, 1994). Specifically it provides a 'buffer' of time that can be used if unforeseeable complications or if interruptions arise while completing the task. If not, the 'extra' time can be used in other productive ways.

However, will the extra time be used in such a way? The answer, it is argued, is probably not and the reason is best expressed by Parkinson's first law (Parkinson, 1957, 1980).

Simply put Parkinson's first law suggests that work expands so as to fill the time available for its completion (Parkinson, 1957). Although the tongue-in-cheek 'law' was originally applied at the group level (specifically bureaucracy) (Parkinson, 1980), or indirectly at an individual level (Aronson & Gerard, 1966; Aronson & Landy, 1967; Landy, McCue, & Aronson, 1969), more recently Brannon, Hershberger and Brock (1999) have provided direct evidence of the effect at an individual level.

In their first experiment, Brannon et al. (1999) initially lead participants to believe that they had to complete four trials of judging different sets of facial photos to a set criterion. However, only three were completed, one group was told that the fourth set was withdrawn from the study at the end of completing the second set, while the other group was told this at the end of the third set. Upon completion of the third set participants were also asked a number of questions concerning the experiment including their estimation of how long each set had taken them and whether they felt that the cancellation of the fourth set had effected the amount of time they had spent on the third set. Brannon et al.(1999) found that those participants who were informed of the cancellation before starting the third (last) set took significantly longer to complete it – they 'dallied' on the third set. This result was confirmed in three subsequent similar experiments. In addition, participants appeared to be unaware of this dallying on the third set in that although, as mentioned, the experimental group took significantly longer to complete the third set, there was no significant difference between the two groups estimated duration of the third set. Further, most participants in the experimental group felt that the cancellation made no difference to the amount of time they spent on the last set, and more importantly no participant mentioned issues such as 'tried harder' or 'tried to be more accurate' or 'spent more time on the pictures'.

In a fourth experiment Brannon et al. (1999) extend the generalisability of the phenomenon by demonstrating that the effect also occurs with inherently unpleasant tasks, and that the degree of dalliance is proportional to the amount of 'spare time' (i.e., the magnitude of the cancelled work). In addition, they demonstrated that dalliance was not associated with increased performance, concentration or effort. However, it is worth noting that this result may not generalise to a true work situation were motivation levels are likely to be higher.

Taken together these results strongly suggest that it is unlikely that any remaining scheduled time will be used in a productive way. Alternatively, it is suggested that people will slow down so as not to finish early while still keeping to schedule. A view reinforced by Brannon et al. (1999) that if "...excess time arises, dalliance by workers on their present task could amount to substantial and costly inefficiency" (p. 155).

Additionally, research suggests that overestimating the time to complete a task will have a negative rollover effect on the speed of completing similar future tasks. Research by Aronson and Gerard (1966) and Aronson and Landy (1967) demonstrated that a person who is given an excessive amount of time to complete a task will take significantly more time to complete a similar subsequent self-paced task than a person who is not given excessive time to complete the initial task (note: it would be interesting to see whether the opposite effect occurs, specifically if people are 'forced' to complete a task in a shorter time than 'normal' will this result in less time be allocated to a similar task in future?). Although, not quite the same thing, it is suggested that the same effect is likely to occur when scheduling the completion of similar tasks. A person may tend to successively overestimate the 'actual' time required to complete similar tasks.

It may be possible to apply Parkinson's law to the situation whereby task completion times are underestimated. Specifically, that a greater amount of effort will be expended on a given task when 'tight' time restrictions are placed on its completion than when there are fewer time restrictions (Parkinson, 1980). This application of the 'law' suggests that a degree of underestimation in respect to the scheduling of to-be-completed tasks could have a positive effect on personal productivity by enabling more to be done in less time. This type of reasoning has some support in the literature, as well as in laboratory and field settings (Bryan & Locke, 1967; Latham & Locke, 1975). For example, Latham and Locke (1975) demonstrate that logging crews increased their output as time restrictions were imposed.

Given this fact, should a tendency towards slightly underestimating the expected durations of to-be-completed tasks be encouraged? It is suggested that on the whole it should not. Although this strategy may be useful for some individuals who 'need' constant time pressure in order to work efficiently, for most people such pressure will tend to have a negative effect on productivity. However, that said, task duration underestimation could be viewed as a useful strategy when scheduling tasks with a large potential duration variability (for example, mundane tasks like putting letters in envelopes). Although even with these types of tasks, a point will be reached whereby the task cannot be successfully completed any faster. Presuming the person repeatedly allots less time to its completion, sooner or later the task will not be able to be completed in the allotted time.

Chapter 4

Understanding expected duration estimation

As mentioned earlier, the term 'expected duration estimation' (Burt & Kemp, 1994) has been used to describe the process of estimating the duration of to-be-completed tasks or events. Chapter 4 will attempt to clarify the process of making an expected duration estimate. During the discussion my process model of expected duration will be introduced. Time management, specifically the task scheduling component that was discussed in the previous chapter, will be used as a paradigm in which to develop and examine the model. The majority of the chapter is concerned with discussing the model's four main components: 1/ searching memory for similar tasks or events to the task or event which is to be estimated, 2/ gauging the appropriateness of the remembered tasks or events, 3/ what is labelled the 'retrospective process', and lastly 4/, what is labelled the 'expected process'. As part of this discussion the four empirical experiments undertaken as part of this thesis are introduced.

4.1 What type of duration estimation is the scheduling of a to-be-completed task – experienced or remembered?

Before introducing my model of expected duration estimation, consideration of the paradigm this type of estimation best fits needs to be undertaken – prospective, retrospective or a third new 'expected' paradigm?

Following from the seminal work of Burt and Kemp (1994), a recent study by Francis-Smythe and Robertson (1999) further explored people's ability to estimate the duration of to-be-completed tasks (expected duration) and their self-report of the use of time management practices. The study also collected prospective and retrospective duration estimates, as it was suggested that good time managers should also be accurate at these types of duration estimates. By utilising an arguably more appropriate self-report measure of time management behaviours (The Time Management Behaviour Scale) than Burt and Kemp (1994), they found some support for the view that people who perceive themselves as being good time managers are more accurate at expected duration estimates. An interesting finding of this study was that people who rated themselves as good time managers tended to estimate time as passing more quickly than it actually did. They suggested that this may be a motivational strategy designed to enhance a sense of control over time that will help them to be on time for the next task. What Francis-Smythe and Robertson (1999) appear to be suggesting is that these 'good' time managers will feel as if they are in control of time because they will tend to find that it is earlier than they think it is when they check the time before moving on to a new task.

Although Francis-Smythe and Robertson (1999) discuss some interesting ideas concerning the relationship between expected, prospective and retrospective duration estimates, for the following reasons it is very difficult to interpret their findings. Despite it professing to improve our understanding of how people estimate the duration of to-be-completed tasks and the role this plays in managing one's time, it is suggested that the situation which the participants were put in was so artificial that the results cannot provide much information about the 'real-world' situation of time management and expected duration estimation. The biggest problem was that the participants were hypo-vigilant towards temporal issues and time management in general – participants were told at the onset it was a time management study, watches were removed, and throughout the study they had to carry around and operate a stopwatch (having the face covered is of little consequence). In fact, it is suggested that this temporal hypo-awareness made so-called retrospective duration estimates prospective in nature. It is suggested that the pattern of results could have come about through a self-fulfilling prophecy.

It is worth noting that many of the above concerns can also be made of Burt and Kemp's (1994) study. Participants in this study were required to make duration estimates before completing the tasks (additionally, temporal aspects of the experiment were highlighted by requiring participants to remove their watches, fill in temporally related questionnaires, and start and stop stopwatches) - hence similar to Francis-Smythe and Robertson's study, the duration estimates requested after the tasks might be categorised as prospective in nature. It is important to remember that it is not the declared paradigm that necessarily defines the estimation - more important is the subjective paradigm as perceived by the participants (Zakay, 1990).

Returning to the original question regarding the paradigm that best fits expected duration - do these estimates fit into the retrospective paradigm? Expected duration estimates are not what we would typically call a retrospective estimation even though the underlying process may be very similar. For one thing the subjective duration estimates of a particular task/event are not (in fact in most cases cannot be) comparable to the objective duration of the 'actual/remembered event' – a defining feature of this paradigm. At best it can only be inferred by measuring the objective duration (the actual time taken) for the future event of which the duration has been estimated. Additionally, congruency between the objective duration of the remembered event and the future scheduled event will vary greatly depending on how closely the event matches the person's schematic event memory. Moreover the to-be-scheduled event will almost certainly be a lengthened, shortened, or moderated version of the remembered event – in fact it will quite likely involve the 'blending' of more than one remembered event together to form the new to-be-scheduled event (see following section). However, that said, it is clear that most expected duration estimates involve making some form of retrospective estimate/s as part of the process.

It addition, it could be argued that in some cases, real-world expected duration estimation is somewhat prospective in nature. This will certainly be the case for regular 'schedulers' given that they are routinely (usually on a daily basis) required to estimate how long a task is going to take them, which must lead to a heightened awareness of temporal aspects of all daily tasks. Even for those who are only occasionally required to schedule the completion of a to-be-completed task, the inherent temporal structure of the 'work-day' will probably result in the same effect.

Overall, it is argued that retrospective duration estimate/s (and therefore research findings concerning this paradigm) will be an important part of most expected duration estimates. However, as mentioned above, some expected duration estimates might also involve prospective type estimates (e.g., heightened temporal awareness is likely in work environments where the scheduling of to-be-completed tasks is a very regular activity). Based on our presently limited understanding of expected duration estimation it is difficult to decide whether these types of estimates represent a truly different paradigm. In light of this fact it is suggested that at present these estimates can usually be best categorised as a special type of retrospective estimation. Therefore a review and discussion of relevant retrospective duration estimation research will now be undertaken.

Assuming that expected duration estimates are at least partly reliant on a type of retrospective duration estimation, what is known about these types of duration estimates? As should be clear from earlier discussions, no definitive agreement exits on how to explain remembered (retrospective) duration, however most accounts focus on the role of memory processes (Block, 1990). Most researchers agree that retrospective duration estimates are based on more than the degree of recallability of events from the time period (Block, 1990; Boltz et al., 1998; Loftus et al., 1987). Some earlier research suggested that people remember a duration as being longer if they can remember more things about it - if there are more 'events' available in memory then the time period is likely to be estimated as longer (Ornstein, 1969; Vroon, 1970). However, such duration estimates are not based solely on the degree of recallability - other processes such as the amount of contextual change (Block, 1985) or degree of structure (Boltz, 1998c) also appear to be involved. Block (1990) summed this up by suggesting that "people remember the duration of the time period by relying both on event information and on contextual information associated with the event" (p. 30).

More specifically, there is evidence to suggest that the objective length of the duration may moderate the resulting subjective duration estimation. Block and Zakay's (1997) meta-analysis suggested that greater levels of underestimation are associated with lengthening stimulus durations. They reported the average duration estimation ratio (the ratio of subjective to objective duration) for studies using short durations (5.0 - 14.9 sec) to be 0.90, whereas for moderate duration studies (15 – 59.9 sec) and long duration studies (60.0 sec or longer) it is 0.78. This finding can be explained by some, but not all, memory based models. For example, utilising Ornstein's (1969) storage size hypothesis, Block and Zakay (1997) reported that there seems to be no reason to think that the encoded stimulus event needs more storage space as the duration lengthens. Alternatively, Block and Reed's (1978) contextual change model does assume that the amount of change per unit of time will decrease as a person continues with a certain type of activity. This finding was also reflected in the lesser slope of the psychophysical function for retrospective, compared to prospective, estimates found in many studies (see Block & Zakay, 1997). Block and Zakay (1997) suggest that whatever memory information is used in forming remembered duration, more encoding appears to occur during the start of the duration than at any other time, reflecting a process similar to that involved in positive time-order effects whereby participants judge the first of two equal duration events as being longer (Block, 1985).

It also appears that retrospective duration estimates are moderated by stimulus complexity. Block and Zakay's (1997) meta-analysis found that average duration judgement ratios were greater for studies using complex duration stimuli (0.94) than for studies using simple duration stimuli (0.75). Both storage size and contextual change type models can adequately explain this finding. For instance, the person may encode more interpretations of a more complex stimulus that will result in more changes in processing context (Block, 1990).

Finally, retrospective duration estimates tend to be more variable than prospective (both within and between participants). This has been interpreted as suggesting that whereas people use similar cognitive processes for prospective estimates, they make use of a wide variety of cognitive strategies (both within and across participants) in retrospective duration estimates (Block & Zakay, 1997). In addition, there appears to be a trend towards larger coefficients of variation (the standard deviation divided by the mean estimates) as stimuli duration increases. As Block and Zakay (1997) suggested: "As duration increases, different processes may subserve duration judgements in different participants, especially for remembered duration" (p.192).

Lastly, before introducing my model of expected duration estimation, it needs to be highlighted that there are important conceptual and practical differences between estimating the duration of a relatively short duration task of an hour or so compared to one that may last all day or even span multiple days. On the one hand, estimating how long it will take to complete tasks of actual duration of a few hours is primarily one of estimating the expected duration of the task per se. On the other, when estimating the duration of a longer task that could potentially span multiple days it is argued that the focus is on estimating the expected completion date not the actual duration of the task. Expected duration on this longer time scale involves numerous other processing steps and inevitably additional unique biases. For example, in addition to being able to estimate the required duration of the task, a person also needs to be able to factor in numerous additional temporal variables (e.g., sleeping, eating, sickness, and recreation to name but a few). Although it is acknowledged that there is no clear differentiation, because while completing a relatively short task a person may have to visit the toilet or grab a snack, clearly the longer the task the less the scheduling of its completion is a matter of 'pure' duration estimation. The model proposed below primarily explores the process of 'pure' expected duration estimation (i.e. tasks of an actual duration up to a few hours).

4.2 Development of a model that explains expected duration estimation

Figure 4 graphically represents the proposed process a person undertakes in order to estimate the duration of a to-be-completed task. The model draws upon, among others, Burt and Kemp's (1994) 'reconstructive processes' (see section 2.4) of expected duration estimation, and also aspects of the 'verisimilar representation' perspective (discussed later in this chapter) put forward by Michon (1990).

Although temporal information processing is often automatic there are many circumstances where a person would need to process this information on a more conscious level (Michon, 1990). It is argued that, to a degree, making an expected duration estimation fits into this category. Michon (1990) suggests that one effective type of temporal conceptual structure is a 'verisimilar representation' - for instance, when you are asked to respond to a question like "how long will it take me (a friend) to get to the beach?" To effectively answer this question Michon (1990) suggests that you must be able to represent the spatial distances and superimpose on this an appropriate time scale based on your analysis of the person's walking pace. However, although a person may report that they 'play-back' some sort of 'verisimilar representation' of a past event or task when asked to make an expected duration estimation like the one above, it is argued that they are in fact most likely reconstructing (Burt & Kemp, 1994) this event from memory traces.

There are four main components outlined in the model depicted in Figure 4 that attempt to describe this reconstructive process. The first involves searching memory for similar tasks or events to the task or event that is to be estimated. A second component of the model involves gauging the appropriateness of the remembered tasks or events. This stage is suggested to be heavily reliant on what will be referred to as schematic event/task memory. The third component referred to as the 'retrospective process' whereby the person estimates the duration of the remembered/reconstructed events/tasks. Finally, the fourth component labelled 'expected process' involves coming up with the actual expected duration estimation and is presumed to be moderated by temporal bounding and rounding processes. Each of these four interrelated components will now be discussed.

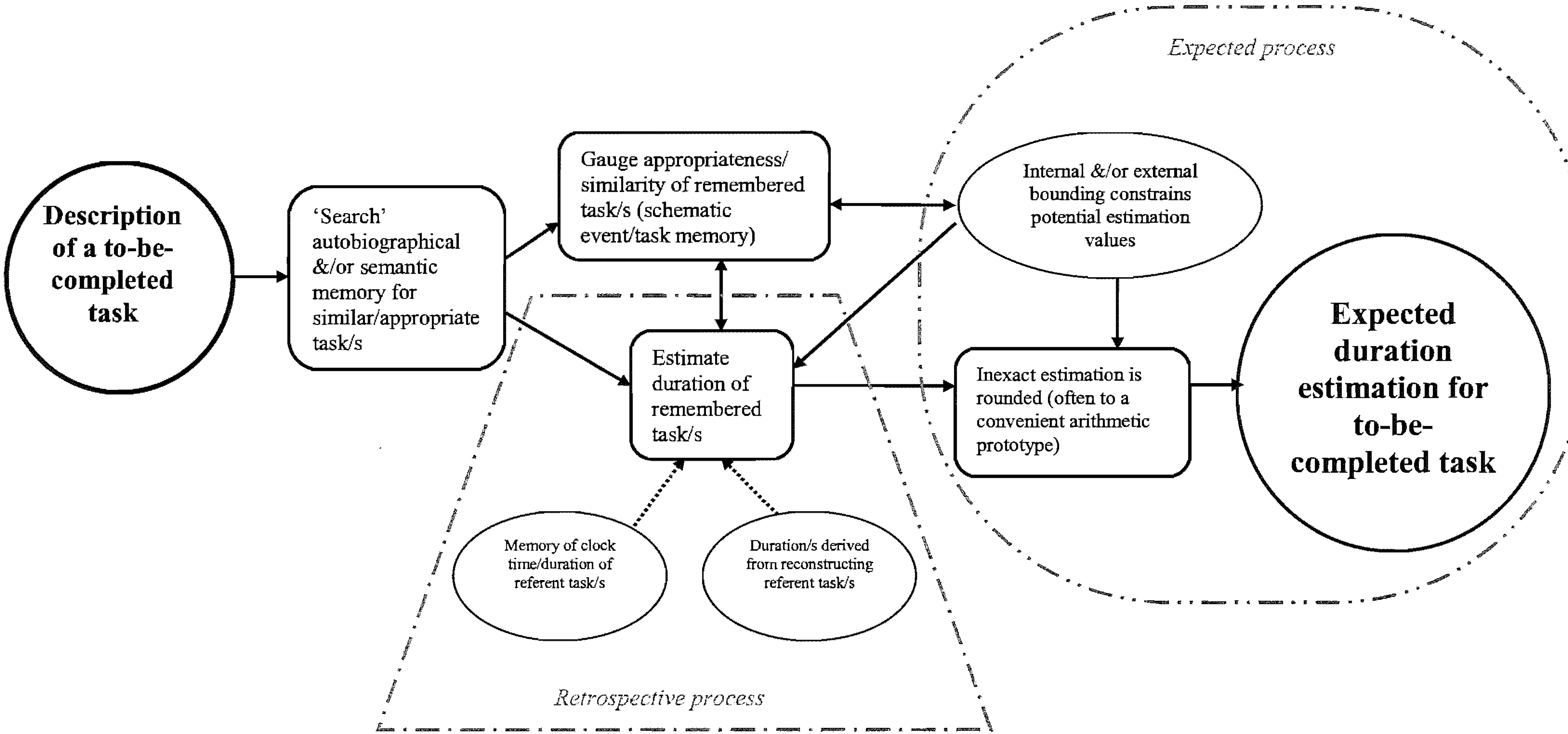

Figure 4. A process model of expected duration estimation as utilised for time management scheduling purposes

4.3 Retrieving potentially relevant memories

One of the first processes a person may undertake when attempting to estimate the duration of a to-be-completed task is the 'searching' of autobiographical memory for a similar task/s that the estimator has completed (see Figure 4). It is presumed that both autobiographical incidents (a person's memory of events which happened in a specific time period) and personal semantic memory (factual knowledge concerning the person's past like the names of work colleagues, and friends' contact information) components of autobiographical memory (Kopelman, Wilson, & Baddeley, 1989) will potentially be utilised when attempting to estimate the duration of a future task. Furthermore, it should be noted that it is likely that general semantic memory (knowledge concerning objects, facts, meanings, and concepts) will also be a source of potentially useful information especially where the person does not remember the 'event' of having completed a similar task. Although this type of knowledge is typically not temporally-specific it may be helpful in estimating the duration of a future tasks. For instance, imagine that a person is required to schedule the completion of a performance development meeting with a subordinate. Although the person has never actually been involved with a performance development meeting per se, semantic knowledge of the term will be helpful for estimating the likely duration. Furthermore, this semantic knowledge may cue more useful memories

It is worth pointing out that the most likely situation is that knowledge concerning the to-be-estimated task/event is likely to be cued at a number of different levels of specificity (Conway & Pleydell-Pearce, 2000). As far as autobiographical knowledge is concerned Conway and Pleydell-Pearce (2000) describe three broad levels of specificity. At the broadest level are what they refer to as 'lifetime period' memories which contain thematic knowledge about common features of a particular period of a person's life. At a more specific level are general event memories, which may be made up of a number of repeated similar events (Robinson, 1992). Finally, of greatest utility for the present purpose are what Conway and Pleydell-Pearce (2000) refer to as 'event-specific knowledge' which are vivid memories of a specific event. Importantly for the present focus, Conway and Pleydell-Pearce (2000) suggest that it is likely memories at lower levels of specificity will cue more specific and useful memories.

The best possible scenario from a duration estimation point-of-view would be if the person can construct memories containing 'event-specific knowledge' (Conway & Pleydell-Pearce, 2000) pertaining to the to-be-estimated task/event. During these ideal (and most probably rare) circumstances where a person can retrieve detailed and specific information concerning the event, the reconstruction may come close to a 'replaying' of the event. For example, Poynter (1989) comments on the fact that participants in his retrospective duration estimation studies "... frequently claim that they mentally replay (or scan) the visual events filling an interval as a strategy for reproducing the interval duration" (p. 311). Similarly, in his discussion of prospective remembering (see section 3.7), Payne (1993) suggests that an intention is encoded by mentally projecting it, which often involves " 'backward' imagining of precursive actions" (p. 91).

At the other end of the continuum are situations where, faced with the description of the task/event, the individual is only able to draw upon thematic knowledge concerning a period of their life (e.g., working as an academic in the

1980s) which seems to have similarities with the task/event for which they are required to schedule. However these low specificity memories may cue more specific memories concerning 'general events' (e.g., the marking of assignments) (Conway & Pleydell-Pearce, 2000). Although less specific than 'event-specific knowledge', this type of memory it likely to be useful when faced with scheduling the specific task or event for the first time (e.g., the marking of a specific group of assignments) in that they often represent memories of sets or groups of events that are linked together by a common theme (Robinson, 1992).

Evidence which demonstrates the value of trying to reconstruct events based on past memories can be found in studies which have looked at the use of imagery in making retrospective duration estimates. For instance, Pigott, Brigham, and Bothwell (1990) found that people were more accurate at retrospectively estimating the duration of a staged crime if they were encouraged to reconstruct the event with imagery-rehearsal. Likewise, Yarmey and Yarmey's (1997) retrospective estimation study found that people in a field situation tended to greatly (300%) overestimate the 15-second interaction they had had with a 'confederate' whereas those who were encouraged to use imagery-rehearsal when making their estimation were relatively accurate.

Furthermore, the verisimilar nature of these reconstructions is provided by studies from Hornik (1984) and Cottle (1976), which demonstrate that people employ spatial schemes when making retrospective estimates of duration. For instance, a field study by Cottle (1976) found the length of the customer service line in a supermarket was positively associated with the retrospective estimation of the duration spent waiting for service.

4.4 Gauging the appropriateness of the remembered tasks or events and the role of schematic event/task memory

The next stage of the estimation process involves two interrelated cognitive tasks – remembered task/s appropriateness analysis and remembered task/s duration estimation (covered in the next section). Gauging the appropriateness of the cued memories is suggested to involve categorising these memories by their usefulness in relation to the to-be-scheduled task/event. This categorisation process will most likely draw heavily on semantic knowledge the person possesses concerning the task/event description. For instance if the person is required to estimate how long it is going to take them to 'balance a ledger unassisted', their understanding of the word 'unassisted' may mean that memories concerning balancing a ledger using a calculator may be categorised as being less useful than memories of 'pencil and paper' type arithmetic.

Further, it is argued that many of these memories will be schematic in nature – 'memory of a particular type of event' for instance attending a business luncheon. Although everyday events are individually encoded they will tend to lose detail and acquire a "schematic or prototypical character" (Michon, 1998, pp. 207). It is argued that these schematic event memories may be very useful in making an expected duration estimation. As Michon (1990) points out, adult humans have "access to a large repertoire of temporal standards for concrete, everyday, 'natural' events, associated with scenarios (scripts, frames), not only in order to efficiently execute routine activities, but also in order to explain and communicate" (p. 43). Similarly, Schank (1999) has proposed that much of human behaviour in everyday situations is guided by scenarios/explicit representations of remembered situations that are sufficiently close to the prevailing situation as to serve as a guide to further action. Over the course of a person's life they build up a repertoire of useful scenarios (Schank & Abelson, 1977). As each sort of scenario includes an implicit temporal structure (Michon, 1998) a person who is exposed to a similar task will be able to cognise whether it is unfolding in a temporally plausible way.

4.5 The retrospective process of estimating the duration of remembered events

The other interrelated cognitive task is to estimate the duration of this/these remembered tasks. A number of researchers (e.g., Boltz, 1998b; Burt, 1992) have alluded to the fact that people can potentially estimate the duration of an upcoming task by either utilising remembered clock time or by estimating the duration of an event 'held' in memory by 'reconstructing' the event. The proposed model (see Figure 4) argues that these are distinct (although potentially complementary) ways in which to base duration estimates of an upcoming task. Firstly the utilisation of clock time will be discussed followed by an in-depth discussion concerning the reconstruction of task durations, especially those reconstructions that make use of schematic task/event memories.

One problem with most of the theoretical work done in this area is that it tends to have been undertaken with the presumption that clocks and other 'objective' cues are not readily available. For example, as mentioned earlier most duration estimation studies are conducted in the absence of watches and clocks. However, as mentioned, this is clearly not the real-world case. Clocks and watches are omnipresent in modern society (Campbell, 1990; Michon, 1998). This is especially the case in a work environment where the majority of task/event scheduling occurs. It is argued that it is difficult, if not impossible, not to be aware and encode directly temporal aspects of the workday. In support of this view Francis-Smythe and Robertson (1999) suggest that good time managers appear to rely heavily on objective temporal cues such as watches. They go on to suggest that the tendency for people in their study, who rated themselves as good time managers, to overestimate time in passing may reflect a cautious reaction to not having these cues.

Furthermore, the encoding of clock time is in line with the view that in many cases expected duration estimation is somewhat prospective in nature. For obvious reasons prospective studies are normally undertaken without the assistance of 'accurate' time keepers (watches, clocks). However, in a real-world situation this is often not the case. If a person 'knows' (either implicitly or explicitly) that they are going to be required to recall the duration of an upcoming task (prospective) the easiest/most fecund way would be to utilise a watch or clock.

Is clock time really different from the encoding of any other forms of 'change'? It could be argued that there is no meaningful difference between the encoding of clock time and the encoding of any other forms of change, which duration estimates could be extrapolated from. The differentiation being made in the present model is between the duration of the referent event at the time it occurs versus reconstructing the duration of an event at a later date by attempting to reconstruct a somewhat verisimilar representation of the event. It should be pointed out that there are other forms of change from which duration could be inferred (the growing length of text as one types), however it is argued that clock time, by far, provides the most accessible and accurate form of change to infer duration. In a similar vein, it has been suggested that at least on one level we use much the same strategy for estimating duration without clocks as we do with them (Poynter, 1989). This statement suggests that any perception of duration involves perceiving change of some sort whether it is movement of the hands of a clock or the 'growing' length of words freshly written on a computer screen. Although this is essentially true, it is not however the case that they provide an equal resource of temporal information. Firstly, the rate of change evident from the clock will inevitably be more predictable and linear than the change in length of a written piece of work, for example. However, that aside, it is argued there is a fundamental difference between how we perceive and interpret these two different events/changes.

For instance, imagine that there are two people at their respective places of work. The first person sits down at their computer for an unknown period of time and at the end of which they have produced three pages of text before moving on to another task without attending to 'objective' temporal cues (a difficult, if not impossible situation to imagine). The second person looks at their watch before starting to write and then again when they finish, taking note of the 'change'. The next day these same two people are required to estimate how long it typically takes them to write three pages of text. The first person will probably try to reconstruct the duration of the event by 'reviewing' what they most likely see as a verisimilar representation of the event to recreate (probably involving an 'analysis' of the amount of writing – the change- that occurred) yesterday's 'event'. However, the second person will probably find this task significantly easier. It is suggested all they will have to do is remember the time they started and the time they finished and perform a quick calculation to arrive at the estimate. It may be the case that clocks and time telling is so common in our western society that most people in most situations directly encode temporal information concerning day-to-day tasks, and this is fundamentally different from encoding other forms of 'change'. If this is in fact the case, the duration of this event may have been 'automatically' encoded at the time, in which case the duration estimation is solely one of memory.

Although to a large extent our daily lives are governed by clock time, whereby we are continually using watches to consciously monitor the passage of time, there are probably just as many times where we have to estimate duration based on 'subjective time' (Boltz, 1998b). As Michon (1998) points out "we continue to live by our episodic, contextual, experiences" (p. 210) as is evident by the fact that we often find that time 'drags' or 'flys'. It seems likely that many expected duration estimates will be based on reconstructions of schematic events/tasks (or at best seemingly verisimilar representations of a remembered event/task).

In support of this view, Burt (1992) suggested that schematic event durations appear to be developed in memory as part of general event memory and that this schematic duration is used in the reconstructive process. Further, the nature and accuracy (possibly also flexibility) of this schematic event duration is determined by the amount of experience/frequency of exposure to the particular type of event. In addition, the accuracy will depend on how the person perceives the events (the reason for individual differences) (Burt, 1999). If a person is able to identify atypical aspects to the event this information could be used to adjust the estimated duration (Burt, 1993).

Furthermore, Burt (1993) demonstrated that an event's degree of typicality is associated with duration estimation accuracy. Specifically, typicality scores were predictive of both accuracy and whether the estimate was an under or overestimation.

This study provided further support for the view that "the magnitude and nature of estimation error, under conditions of substantial retention interval, are related to the typicality of the actual event" (Burt, 1993, pp. 71). In addition, the findings suggest that the effect of actual event memory on duration estimation typically is not sufficient to completely remove the effects of general/typical event duration information.

Research by Yarmey (2000), Burt and Popple (1996), and Burt (1999) address typicality using the retrospective duration estimation paradigm. Yarmey (2000) undertook an interesting field study of the accuracy of retrospective duration estimates of various invariant (e.g., a computer 'booting up') and variant (e.g., talking to a friend) naturalistic events. One of the useful things about this study for the present discussion is that it deals with a wide variety of naturalistic events of varying objective duration (4 seconds to 80 minutes). In general he found that the events' objective duration was inversely related to overestimation of estimated duration. Whereas the shortest events tended to be overestimated by as much as 100 per cent, longer tasks tended to be accurately estimated with a possible trend towards underestimation for the longest duration (invariant) events. In addition, in line with past research (e.g., Boltz, 1998c) people were significantly more accurate at estimating the duration of invariant events than variant ones. However, this study was somewhat different to what people need to do to estimate expected duration – for example the above study collected duration estimates within seconds of the events' completion.

Another aspect of schematic event memory proposed by Burt and Popple (1996), and expanded upon by Burt (1999), is the effect speed of action has on retrospective duration estimates. Specifically Burt (1999, pp. 353) suggested "the faster the actions in an event are perceived to be, the shorter the estimated event duration". For example, Burt and Popple (1996) demonstrated that people tend to use their general knowledge concerning the relationship between the speed of action and its duration. They showed that participants who were led to believe an event involved running instead of walking provided retrospective duration estimates which were significantly shorter. Similarly, Burt's (1999) second experiment had participants view a 76-second video of a bank robbery before one group was asked to retrospectively estimate the duration of the video and write a narrative describing it straight after viewing, while another group were required to return the next day before being prompted for the same information. One of the main findings of this study was that there was a large degree of variation between the wording participants used to describe the robbery and also variability in the estimated duration. However, somewhat surprisingly, there was no significant difference between the immediate group and the delayed group on either of these measures. Overall there was a general trend toward overestimating the duration of the robbery in both groups. The results revealed a significant negative correlation between the number of action words used and the participants' estimate of the robbery's duration – more action words, shorter duration judgement. Unfortunately the results did not allow for conclusions to be made as to the relationship between the 'speed' (i.e., charged vs. pushed vs. passed) of the action words used and the duration judgement. It would be expected that there would have been a significant interaction effect between the 'speed' of the words used, the total number of action words used, and the duration estimation.

Burt (1999) suggested the direction of the causation of this effect is from the construction of the narrative that describes the event to estimating the events duration. This interpretation is in line with the view that retrospective duration estimates tend to be based on reconstructive and constructive processes (Burt, 1992, 1993; Burt & Kemp, 1991). In order to further develop this idea it would be interesting to see what effect providing the participant with different event durations after they had viewed the video would have on the narrative they produced.

As far as expected duration estimation is concerned, an interesting set of experiments that shed light on the effect of semantic event memory was undertaken by Josephs and Hahn (1995). They suggested that when people are required to estimate expected duration (of various academic type tasks) they tend to trade accuracy in favour of minimising cognitive effort. Their series of studies focused on the quality of information the schedulers received. Overall they found that participants tended to base their estimates on task features that required the least amount of computational effort to process. The resulting accuracy of such estimates was to a large degree dependant on the diagnostic value of these features.

In their first study Josephs and Hahn (1995) asked students to estimate how long they would need to complete a written assignment of either four single-spaced pages or seven double-spaced pages. As predicted students on average allotted significantly more time to the completion of the seven-page assignment even though it contained fewer words. They explained this finding in terms of the fact that although pages are less diagnostic than number of lines they are computationally easier. Although this is an interesting finding it is suggested that it is not an effective test of their theory. As pointed out by Gilbert (1991), people only undertake the type of discounting required in the above example if they are highly motivated – in this case to provide an accurate estimation. However, it is argued that this was not the case - students were motivated to provide an estimate that allowed them 'plenty of time' to complete the assignment, after all they did not want to hand it in late. It is argued that this situation motivated them to give themselves a 'safety net' – an overestimation. As they are not primarily focused on accuracy per se it is not surprising that only surface features were principally taken into account when making the duration estimation. A way to test this hypothesis of generic overestimation would have been to have a group estimate how long it would take them to complete a four double-spaced page assignment.

In their second study Josephs and Hahn (1995) found students estimated the completion of significantly fewer anagrams when each anagram was attached to the front cover of a journal (hence the anagram looked 'bigger'). They suggested that this was because the most salient feature of this task was the size of the 'pile' of anagrams, and so people would use this information on which to base their estimate. One interesting issue is that although they suggest that reducing cognitive effort by relying on surface features of the to-be-estimated task tends to result in people vastly underestimating required duration, this study in fact shows the opposite. In both cases participants completed substantially more (in the order of 2-3 times more) anagrams than they had estimated, in both cases vastly overestimating the actual duration required to complete each anagram. Their third study reported a similar conclusion – people place more weight on page length than more useful, but cognitively taxing, information like font and margin size when estimating the expected duration of reading. In a similar vein are studies demonstrating that people are more likely to complete and return a questionnaire if it is formatted onto fewer pages (see Hornik, 1981).

It is worth pointing out, the tendency for over or underestimation in many of Josephs and Hahn's (1995) studies were influenced, or potentially determined, by experimenter imposed boundary effects, which are discussed later in this chapter. For instance, it is suggested that the trend towards overestimation of the duration of the anagram task (Study 2) was primarily due to expectations set up by the experimenter concerning how long each anagram 'should' take. Participants had 10 anagrams in front of them and 10 minutes in which to complete anagrams. Although they were told more anagrams were available if the 10 were completed, it is argued that the experimenter has inadvertently provided a cue to how many they 'should' be able to complete. Similarly, in their reading studies there was an implicit maximum time in which it would take to read the material. The fact that participants were stopped after a set time only long enough to read a small proportion of the required amount would suggest they were implicitly supplied with unrealistically low boundaries of possible durations hence the tendency for huge underestimates of actual duration.

Although Josephs and Hahn (1995) explain their findings in terms of minimising cognitive effort, another way to look at it is in terms of typicality of to-be-estimated tasks or events, whereby more typical ones were estimated with greater accuracy. For example, when asked to estimate how long it would take you to read the paperback novel in front of you, your accuracy would be dependant on how typical the book's attributes were – its font type and size, its grammatical complexity, its paper thickness, the size of its margins. In the first study single-spacing may have been more typical of what students were required to do. Likewise, it is a very atypical situation to have to complete anagrams attached to the cover of journals.

Interestingly, one form a schematic event memory that has received very little attention is the number of presentations required to 'build' such a memory? Experiment 1 (Chapter 5) investigates the effect a single exposure has on the updating/building of a schematic event/task memory. It is argued that saliency (in the form of recency) of presentation will have a significant effect on schematic event memory and future expected duration estimations, which cue this schematic event memory.

4.6 The expected process – two factors which influence the accuracy of the resulting expected duration estimation

Finally, appropriateness of remembered similar task/s and duration of these task/s are then combined in the ways outlined below to produce an estimation of the to-be-completed task. In the simplest (and unlikely) situation this would involve directly transposing the remembered duration of a single (identical) event to the estimation of the to-be-completed task. It is likely the situation would be more complex than this, involving the 'splicing' of a number of reconstructed tasks' remembered durations resulting in a single duration estimation for the to-be-completed task. This 'splicing' would involve making adjustments to the resulting expected duration based on the appropriateness of the remembered task/s. It is argued that due to the perceived verisimilar nature of the reconstructed episodes they are able to be played back and most importantly manipulated and combined with other reconstructed episodes if required (Michon, 1998). This process could be in three forms (often a combination of all three) corresponding to the three possible types of event similarity mentioned above. Firstly, a number of less complex/shorter remembered events could be sequentially ordered to 'arrive' at an estimated duration for a future 'complex' task. Secondly, by analysing the remembered duration of a slightly less demanding task and a slightly more demanding task 'cued' from memory. Thirdly, and similarly, by analysing the remembered duration of two or more 'similar' tasks 'cued' from memory.

As can be seen in Figure 4 there are two factors included in the expected process that are predicted to moderate the accuracy of the final expected duration estimate – externally and/or internally imposed temporal boundaries and the tendency to round estimates to convenient arithmetic prototypes. The final part of this chapter will be devoted to an in-depth discussion of these two factors.

One of the potentially interesting, and to a large extent unavoidable, situational variables that is likely to significantly effect the real-world accuracy of expected duration estimation are temporal boundaries. By and large, most to-be-estimated tasks or events will have either a self or external imposed upper boundary on how long a task is likely to take, or can take. For instance, most work tasks have an externally derived time in which they 'need' to be finished (e.g., if you are giving a team presentation at 4 pm today it is obvious that the accompanying PowerPoint presentation needs to be finished before 4 pm – you have no real choice in the matter). Further when given a task to complete the individual will most likely have a temporal boundary in mind concerning how long they can possibly spend on the task due to other responsibilities or focuses. This upper limit may truncate resulting duration estimates. Huttenlocher, Hedges, and Bradburn (1990) argue that, as far as retrospective estimates are concerned, this truncation will result in an underestimation of actual duration.

In support of boundary effects, Huttenlocher, et al., (1990) demonstrated that peoples' estimates of reported duration since a particular event (an autobiographical memory) is not distributed evenly (as they actually were) but truncated (reported as occurring more recently than they actually did), creating a forward bias of reported date/duration (duration underestimation). It is argued that when a memory is inexact, people will inevitably 'create' boundaries concerning maximum possible durations, and forward bias (underestimation of actual duration) will necessarily arise (Huttenlocher et al., 1990; Huttenlocher, Hedges, & Prohaska, 1988).

In addition, Hornik (1981) suggests that if a person "lacks memory or retrieval variables, his or her perception of time is easily influenced by temporal values presented as cues prior to or during the task" (p.244). Hornik (1981) conducted a study that examined the effect that predetermined expectancy of duration would have on a person's decision to complete a mailed out questionnaire (although actual average completion duration was 28 minutes, participants were lead to believe it would take them either 20 minutes, 40 minutes or no time was mentioned). Hornik found that the prior temporal cue (or lack of one) had a significant effect on retrospective duration estimates of questionnaire completion duration, with the 20 minute cue resulting in the shortest estimate, followed by the condition which provided no temporal cue, and then the 40 minute cue.

Furthermore, time stress has been shown to affect the amount of time allocated to the completion of an upcoming task. In this context Hayes-Roth (1980) undertook an interesting study that investigated the role of cognitive and motivational factors in influencing expected task duration estimation. One of her underlying assumptions was that time stress increases the tendency to underestimate required time – the more difficult it seems to be to fit all tasks in within the known time constants, the stronger the tendency to underestimate time requirements for individual tasks. It is suggested that this tendency can partly be explained by the fact that people will be inclined to have a natural desire to accomplish all tasks under consideration. It is assumed that people realise there is a certain amount of variability in the time that a task can be performed. Under time stress, the desire to perform all of the actions seems to bias people's duration estimates toward the lower bounds of these distributions.

Hayes-Roth (1980) conducted a number of studies to test these predictions. In these studies participants were given a 'city' map with buildings and streets marked on it along with a list of desired errands, a start time and location, and an end time and location (total allowable duration tended to be around 2-3 hours). Participants were given a 'problem', which included a number of errands and they were required to indicate which errands they would accomplish and in what order and routes taken. In one of these studies she manipulated the number of desired tasks and the available time resulting in four conditions. In three of the four conditions participants underestimated completion times by over 50 per cent (the condition where participants tended to overestimate task completion duration was the only one where time available exceeded required time). Specifically, she found evidence that time stress was significantly related to participants' underestimation of task duration – underestimation increased as the number of desired tasks increased and also as the available time for performing the task decreased. It is worth noting that participants did tend to plan to complete significantly fewer tasks as time stress increased, however they failed to reduce it sufficiently to meet actual time constraints.

It is also worth pointing out that in the present context of estimating expected duration this effect may be even more important, potentially providing bias in two distinct – yet related - and cumulative ways. Firstly, like Huttenlocher, et al.'s (1990) autobiographical memory studies it is suggested that when people try to estimate the duration of similar tasks they will tend to impose a boundary on how long that task took, such as 'it could not have taken longer than one morning otherwise I would not have been able to get my regular work done'.

Secondly, when it comes to using that information to estimate how long the present task is going to take there will tend (in 'normal' real-world situations) to be an imposed boundary on how long the task 'can' take. Often it will be externally imposed. An externally imposed boundary could be in the form of a deadline imposed by a supervisor in a work situation or a teacher or professor in an educational environment. Likewise, individuals often provide their own upper limit as well as/or instead of an externally derived one – 'I must get this done by Monday otherwise I will have no chance of getting my monthly bonus' or 'This task can only take me 15 minutes max. otherwise I will not have time to meet Frankie and May for morning tea'. It is argued that these two boundary effects will have the cumulative effect of biasing people towards allocating (typically) less time to the completion of a task than they would have otherwise and, based on the findings of Huttenlocher, et al. (1990), often underestimate actual duration.

The effects of boundaries on expected duration estimation might explain some of the divergent results found in the literature. For instance, unlike many other similar studies (e.g., Burt & Kemp, 1994), Francis-Smythe and Robertson's (1999) expected duration estimation experiment (described earlier) did not find evidence of a general trend towards overestimation of task durations. It may be the case that these results can partly be explained by the greater bounding cues inherent in this experiment. Specifically, Francis-Smythe and Robertson's (1999) experiment components were segmented thereby creating more distinct boundaries to the possible time each component could take – *en bloc*. This was in contrast to Burt and Kemp's (1994) study where many tasks were scheduled/estimated within one 'segment'. Additionally, another more subtle type of bounding effect could have contributed to people estimating much less time than they otherwise would have. Participants in the

Francis-Smythe and Robertson (1999) study were required to estimate expected duration in seconds, which provides a distinct boundary on possible expected durations. By asking participants to provide estimates in seconds, the researchers are giving a salient cue to the potential duration (Huttenlocher et al., 1990). In the Francis-Smythe and Robertson study the median actual duration was 349 seconds, which are a lot of seconds (people would probably normally estimate such a duration using a 'minutes' temporal scale).

It seems evident from the research reviewed that temporal boundaries which create real time pressures for the completion of a task will result in less time being allocated to their completion. A more speculative claim is that the same truncation of expected duration estimations will occur when the temporal boundaries are more remote (i.e., when there is plenty of time to complete the task). Experiment 2 (Chapter 6) investigated this claim by comparing the expected duration estimates for three tasks under three different remote temporal boundary scenarios.

Attention is now directed towards the second factor predicted to effect expected duration estimation accuracy – the rounding of estimates (see 'expected process' component of the model portrayed in Figure 4). Overall it is argued that because of the inexactness of people's reconstructions of relevant memories, and temporal estimations of these memories, they will tend to round their expected duration. Furthermore, it is argued that this rounding will often be rather subtle (but no less significant as far as accuracy is concerned), in that it will be in the form of a convenient arithmetic prototype temporal value. Research to support this claim will now be reviewed.

As was mentioned in Chapter 3, there is a body of research that addresses the duration estimation component of task scheduling. Studies that have looked at task-duration estimation accuracy of relatively long duration tasks (i.e., greater than one day) report that participants tend to underestimate task completion durations (Buehler et al., 1994; Josephs & Hahn, 1995). Conversely, studies incorporating shorter duration tasks (less than 30 minutes) report that participants tend to overestimate task completion duration (e.g., Burt & Forsyth, 1999; Burt & Kemp, 1994; Forsyth, 1998), although significant overestimation is not always found (e.g., Francis-Smythe & Robertson, 1999).

Studies that have found participants who underestimate task completion times tend to explain their results using a form of the 'planning fallacy', or the tendency to be confident in the belief that although most similar projects have run late this one will be completed as planned (Kahneman & Tversky, 1979). For example, Buehler et al. (1994) suggest that when making time estimates people utilise 'singular information', which involves the construction of narratives and scenarios for completing the specific task as opposed to 'distributional information', which includes past experience of similar tasks. Buehler et al. (1994) suggest that there are a number of things inherent in the process of task duration estimation that cause people to use this flawed strategy. Firstly, they suggest that the forward nature of the prediction tends to reduce reflection on the past. Secondly, they argue that people tend not to have the ability to apply information from a similar past experience, even if it is retrieved. Thirdly, and probably most importantly, where similar experiences are considered, their pertinence to the present estimate is deemed to be low because of the causal attributions made of this past experience (e.g., being late because of some external cause or a specific failure related to that particular task).

Alternatively, the overestimation found in studies using relatively short tasks has been described as a 'safe estimation strategy' (Burt & Kemp, 1994). By overestimating the time required, a person is left with time to spare at the completion of the task, which may lead to an increased perception of time control (however, it is worth noting that although this strategy may result in an increase of perceived control of time it does not necessarily result in effective time management per se - as has been mentioned, it really depends on how the 'spare' time is used). Unlike Buehler et al. (1994), Burt and Kemp (1994) suggest that people do use distributional information to make predictions concerning future task duration. They suggest that future duration predictions are based on knowledge concerning the durations of similar categories of events.

In addition to 'pure' over and underestimation inaccuracy, for the reasons given above, Francis-Smythe & Robertson (1999) allude to the fact that 'rounding' could also effect task duration estimation. When discussing possible reasons for time estimation patterns found in their results they suggest "...rounding to the nearest minute may have taken place (even though participants were asked to estimate in seconds)" (Francis-Smythe & Robertson, 1999, p. 343). Likewise, this potential problem has been indirectly hinted at by Zakay (1990) who points out that any verbal estimate of a duration is prone to error arising from the response bias of reporting durations in round numbers. In support of this view, Hornik (1981) noted that participants in his study tended to report duration estimates in multiples of five minutes.

Furthermore, it is suggested that many of the rounded values found in duration estimation studies represent or 'stand for' a larger category (Smith & Medin, 1981). In other words, five minutes is a "prototype" of this category (Oden, 1987). In the present context it is suggested that although a person may provide expected duration estimates in minutes, their estimates often really represent larger commonly recognised temporal categories (e.g., five, 15, 30, and 60 minutes) – which will be referred to as 'prototypical temporal values' (Huttenlocher et al., 1990). In support of this view, utilising a similar type of task to that of task expected duration estimation, Huttenlocher et al. (1990) found that participants over-reported prototypical temporal values like 7, 14, 30, 60 (week, fortnight, month, and two months respectively) when asked how many days had elapsed since various personal (autobiographical) events. They suggest that these result in a local bias in the regions around each prototypic temporal value. In summary it is suggested that, largely because of the inexact nature of expected duration estimations, a person will tend to round estimates to what they see as a prototypical temporal value. Typically, studies have tried to reduce the influence of this type of perceptual error by requiring participants to estimate durations to the nearest minute or half minute (e.g., Boltz, 1998a, 1998c; Boltz et al., 1998; Hornik, 1984), however given the above discussion this may actually have very little effect on rounding.

Although, this potential problem for duration estimation accuracy has been mentioned in passing by other duration estimation researchers (e.g., Hornik, 1981), it appears that no research has been conducted to specifically investigate this phenomenon. In the present context it is essential to have an understanding of the effect rounding has on estimation accuracy as any potential inaccuracy it causes is likely to be exasperated in 'real-life' task duration allocation where, unlike the Francis-Smythe and Robertson's (1999) study, people are not required/encouraged to make estimates to the relatively fine-grained level of seconds. Typically, daily planners provide very little encouragement to make anything like fine-grained estimates (most diaries/planners, whether digital or paper default at 30 minute or

1hour segments with only a few having the ability to schedule five or 10 minute slots).

Studies by Burt and Kemp (1994), Forsyth (1998), and Burt and Forsyth (1999), that have looked at various aspects of expected duration estimation, indirectly provide support for such rounding to prototypical temporal values. These studies required participants to allocate time for to-be-completed tasks using various daily planners. These tasks had average completion times of between three and 15 minutes, and therefore encompassed probably the most common task times in a work environment (Francis-Smythe & Robertson, 1999). The duration estimates collected in these three studies suggest that, for tasks of these durations, people tend to split (round) their time into five minute segments/prototypical temporal values (this appears to be the case even when participants are using daily planners without pre-determined time intervals) (Burt & Forsyth, 1999; Forsyth, 1998). Specifically, although participants responded on a schematic, which divided time into one minute intervals the medians for all four main task groupings in Burt and Kemp's (1994) study were multiples of five minutes. In addition, expected duration estimates from studies by Burt and Forsyth (1999) which utilised four daily planner types (5, 15, 30 minute intervals, and one with no pre-determined time intervals) and from Forsyth (1998) which used daily planners with no pre-determined time intervals, were predominately multiples of five minutes (90% and 92%, respectively) across all planner types. The type of planner appeared to have no significant effect on this rounding.

Experiments 3 and 4 (Chapter 7) investigated the effect rounding expected duration estimates to prototypical temporal values had on estimation accuracy. It was expected that actual task durations would influence the effects of the rounding of estimates.

Chapter 5

Experiment 1: Updating schematic task/event memory. Task presentation order – contrast effects between short and long actual duration tasks.

Introduction

As discussed in section 4.5, the proposed model of expected duration estimation (Figure 4) embraces the view that schematic event durations appear to be stored in memory as part of general event memory and that this schematic duration is used as part of the estimation process. Additionally, the nature and accuracy of this schematic event duration is determined by the amount of experience/frequency of exposure to the particular type of event.

Inherent in this view is that people will vary in their ability to perceive and judge typicality (the level of congruence with the relevant schematic event memory) of to-be-estimated tasks. As mentioned, Burt (1993) demonstrated that an event's degree of typicality is associated with duration estimation accuracy. Specifically, his study found that events that were atypically long tended to be underestimated, whereas events that were atypically short were overestimated. It appears that specific event duration estimation information in general is not sufficient to completely remove the effects of general/typical event duration information. Overall, people appear to underestimate the degree of atypicality.

One aspect of typically that has not been addressed is the number of presentations required to 'build' a schematic event memory, and the effect of saliency (in the form of recency) in updating a schematic event memory. Most research in this area has looked at typicality, which has been built up over many years of experience and over numerous presentations. For example, the relationship between the speed of action and duration (Burt & Popple, 1996), between the number of action words used and the participants' estimate of the robberies (Burt, 1999), and standard formatting of printed material (Josephs & Hahn, 1995).

However, given the fact that people appear to adopt estimation strategies that minimise cognitive effort (Josephs & Hahn, 1995) it may be the case that saliency of past similar experiences may be a crucial factor in determining typicality. More specifically, it may be the case that a single (recent) exposure to a similar expected estimation experience may alter/effect a future expected duration estimation by 'up-dating' the schematic event memory (Burt, 1993).

It is argued that a high degree of saliency (in the present case, specifically in the form of recency) will have a similar effect to that of repetition in the formation of a schematic event memory and associated duration. Further, it is argued that a person need not have experienced the specific task or its 'duration' (i.e., actually completed the task or experienced the event) in order to update schematic event memory, in that the expected duration process outlined in the previous chapter suggests that the person will most likely reconstruct a type of verisimilar representation of what they believe the task entails. To test these ideas participants were required to either estimate the expected duration of a short 'version' of a task followed by a longer version or vice versa. Based on the trends reported by Burt (1993) the following hypothesis was proposed:

The order of presentation of task, which only vary with respect to scale (e.g., 10 pages of proofreading as opposed to five pages of proofreading), will have a significant effect on the time participants allocate to the tasks' completion. Specifically, participants will allocate significantly less time to the completion of a task if they have previously estimated the expected duration of a shorter similar task. Conversely, they will allocate significantly more time to the completion of a task if they have previously estimated the expected duration of a similar but longer task.

Method

Experiment design overview

The experiment consisted of two between-group conditions. In condition one, participants were required to estimate the duration of four tasks which were presented in the following order – short version of balance task, long version of balance task, short version of proofreading task, long version of proofreading task. In condition two participants were also required to estimate the duration of the same four tasks, however they where presented in a different order from condition one – long version of balance task, short version of balance task, long version of proofreading task, short version of proofreading task.

Participants

Eighty people, with a mean age of 20.8 years, undertaking a stage one psychology course at the University of Canterbury, participated in this experiment (none had participated in any of the three other experiments). Forty were randomly assigned to each of the two conditions. The first condition contained 12 males and 28 females, while the second condition contained 10 males and 30 females. The University of Canterbury human ethics committee approved the experiment.

Materials

As mentioned above each of the two conditions were made up of the same two versions of a balance and proofreading task. As shown below the two versions of each task differed only in magnitude. The two conditions varied in respect to the presentation order of the short and long versions of each of the two types of tasks – in condition one the short version of each task was presented before the long version of the task. In contrast, in condition two the long version of each task was presented before the short version of each task (see Appendix 1). The four tasks are listed below in the form in which the participants received them (task headings were omitted in experimental materials).

Balance task short version:

Five 'bills' (e.g., power bill, phone bill) are provided, along with an account balance sheet. Your task is to enter the 'billed amount' in the debt column *and subtract the amount from the balance, creating a new balance after each subtraction (pen and paper subtraction - no calculator).*

Balance task long version:

Twenty 'bills' (e.g., power bill, phone bill) are provided, along with an account balance sheet. Your task is to enter the 'billed amount' in the debt column and subtract the amount from the balance, creating a new balance after each subtraction (pen and paper subtraction - no calculator).

Proofreading task short version:

A three-page document typed (double-spaced) on A4 paper is provided. Your task is to proofread it for spelling mistakes. Circle each spelling mistake that you find.

Proofreading task long version:

A 13-page document typed (double spaced) on A4 paper is provided. Your task is to proofread it for spelling mistakes. Circle each spelling mistake that you find.

As can be seen from the stimuli in Appendix 1, a space was provided below each of the four tasks for the participant to enter their expected duration estimate. No temporal scale prompts were provided – no hour, minute, or second prompts.

Procedure

Potential participants from stage one psychology laboratories were invited to take part in a study requiring them to estimate how long they thought it might take them to complete four office-type tasks. Interested participants were randomly assigned to one of the two conditions outlined above. Participants were informed that they were to assume they worked in an office-type environment and that they were required as part of their job to complete four tasks. They were also asked to assume that they had the equipment/resources to complete the tasks. Each participant received a self-explanatory questionnaire outlining the requirement to estimate how long they thought it would take to complete each of the four tasks. After each written description of a task, a space was provided in which to enter their estimation. Following completion participants were debriefed and thanked for their participation.

Results

The first, second and third numerical columns of Table 1 show the average, the median, and the range of expected duration estimates for the four tasks for each of the two conditions.

Table 1. The effect of presentation order of tasks that vary in magnitude on expected duration estimation

	Order of Presentation	Mean Estimated Time (&SDs) to Complete (Seconds)	Median Estimated Time to Complete (Seconds)	Range of Estimated Times to Complete (Seconds)
Short Balance Sheet	Presented first (condition 1)	339 (232)	300	60 – 1200
	Presented second (condition 2)	760 (913)	570	60 – 5400
Long Balance Sheet	Presented first (condition 2)	1942 (1957)	1200	300 – 9000
	Presented second (condition 1)	1050 (718)	900	180 – 3600
Short Proofread	Presented first (condition 1)	526 (214)	600	180 – 900
	Presented second (condition 2)	819 (1152)	870	180 – 7200
Long Proofread	Presented first (condition 2)	3247 (4242)	2100	720 – 21600
	Presented second (condition 1)	1863 (877)	1800	600 - 3600

A 2x4 mixed design ANOVA, with the order of presentation (either long tasks first or short tasks first) being the between subject variable and the duration estimates for the four tasks being the within subject variables, was conducted to see whether these difference were significant (Figure 5 depicts the relationship between these variables). The ANOVA revealed a significant main effect for order of presentation ($F(1,78) = 6.61$, $p=.012$) and for the different tasks ($F(3,234) = 34.66$, $p=.000$), however the interaction between these two did not reach significance ($F(3,234) = 2.50$, $p=.06$). More specifically, planned comparisons revealed significant differences between whether the short task was presented first or second for three of the four tasks – short balance ($F(1,78) = 8.00$, $p=.005$), long balance ($F(1,78) = 7.32$, $p=.008$), and long proofread ($F(1,78) = 4.08$, $p=.046$) - short proofread ($F(1,78) = 2.48$, $p=.11$) did not reach significance.

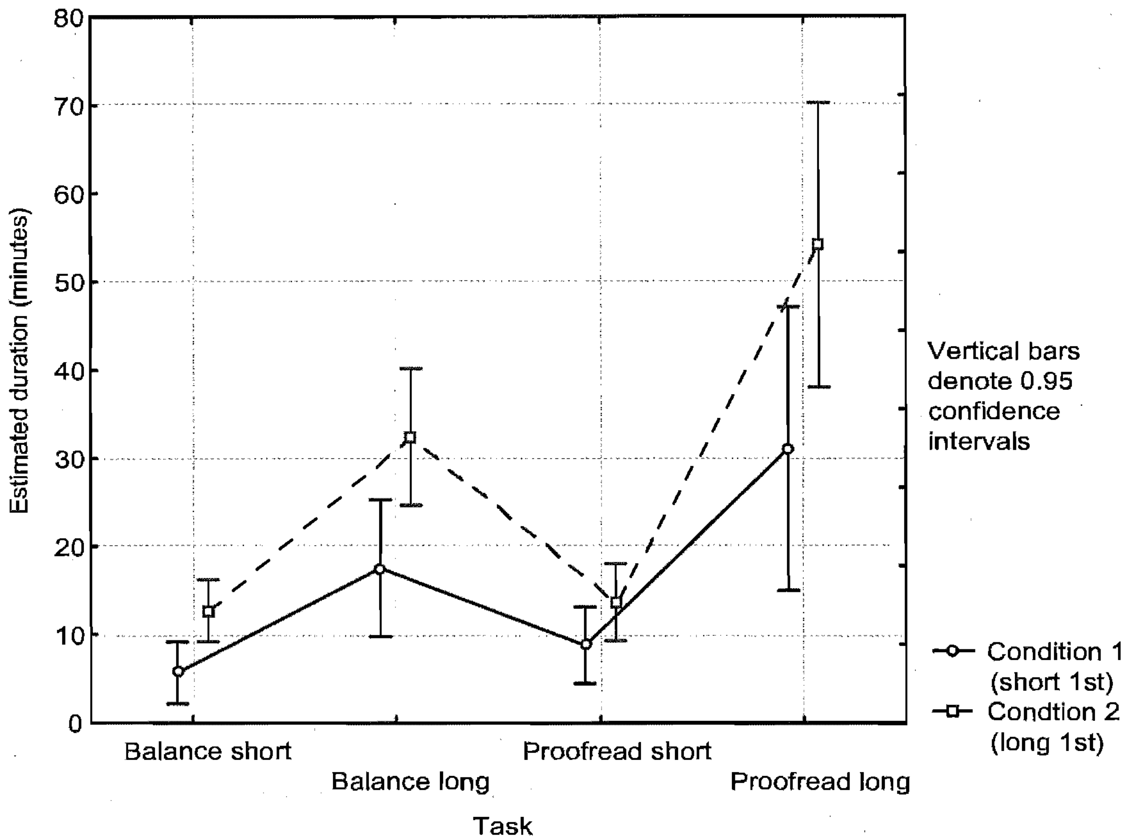

Figure 5. A graphical representation of the relationship between the two conditions in Experiment 1 and the estimated duration of the four tasks.

Overall these results suggest that more time is allotted to relatively short tasks when they are presented after a longer similar task. Conversely, it appears that less time is allocated to the completion of a relatively long task if it is preceded by a shorter task. Strengthening this view, the pattern is consistent across both types of tasks – balance and proofreading.

Discussion

Experiment 1 demonstrated that presenting a highly salient similar to-be-estimated task can affect a subsequent task estimate. Overall there was support for the hypothesis, in that participants tended to allocate significantly less time to the completion of a task if they had previously estimated the expected duration of a shorter similar task. Conversely, they tended to allocate significantly more time to the completion of a task if they had previously estimated the expected duration of a similar but longer task.

These results could be interpreted as suggesting that schematic event memories can potentially be 'adjusted' with a single presentation of a similar task. Although further research is required one can speculate that the 'power' of this single presentation lies in its saliency, in that if participants were required to estimate the completion of the similar task the day before, rather than immediately before, it would not have had such a large effect (if any) on the estimation. Additionally, following on with a 'change in schematic memory' type interpretation of the experimental results, and in line with the reconstructive process involving a verisimilar representation advocated in the previous chapter, the 'up-dating' of schematic event memories appear to occur even when the person has not actually 'experienced' the event firsthand.

Chapter 6

Experiment 2: The effect that remote temporal boundaries have on expected duration estimates

Introduction

Based on the research reviewed in section 4.6 it seems likely that real time pressure in the form of a temporal boundary, either self or externally imposed, will tend to create the tendency for a person to allocate less time to the completion of a task than they would have otherwise. A more appropriate question may be whether the same effect occurs when the temporal boundary is more remote (i.e., when there is plenty of time to complete the task). For instance, it's 8am and a person has to finish a report that will in actuality take about two hours. Will they allocate less time to its completion if it needs to be completed by noon than if it has to be completed by 5pm that day? It is argued that even remote and, objectively speaking, 'non-time pressuring' boundaries will influence the amount of time a person will allocate to the completion of a task. Experiment 2 will investigate the above proposition by comparing expected duration estimates for tasks under different remote boundary scenarios.

The overall view of research reviewed in section 4.6 concerning the effects of boundaries on expected duration estimates is that it reduces accuracy, resulting in an underestimation of the actual completion time. However, is this necessarily the case? Clearly unrealistic boundaries (time pressures) will inevitably result in over ambitious scheduling. However, it is argued that the opposite is also likely – boundaries that are too 'lax' on possible completion times, which result in an overestimation of the duration required to complete the task (at least for those who do not succumb to Parkinson's first law – see Chapter 3). It is argued that 'appropriate' boundaries are essential for accurate expected duration estimation. Experiment 2 addresses this by comparing the expected duration estimates for three tasks within three different remote temporal boundary scenarios.

Hypothesis: The more remote the temporal boundary, the more time participants will allocate to the completion of the task.

Method

Experiment design overview

The experiment consisted of three between-participant conditions. All conditions required that participants estimate the expected completion durations for three tasks. The same tasks were used for all three conditions. Conditions varied in the remote temporal boundary scenario that was assigned to the task description. Across conditions a task was either introduced with an associated 'short', 'medium', or 'long' remote temporal boundary scenario.

Participants

One-hundred-and-thirty-five people undertaking a stage one psychology course at the University of Canterbury participated in this experiment (none had participated in any of the other three experiments). Forty-five were randomly assigned to each of the three conditions. The first condition contained 15 males and 30 females with a mean age of 22.1 years, the second condition contained 10 males and 35 females with a mean age of 21.5 years, while the third condition contained 16 males and 20 females with an average age of 21.2 years. The University of Canterbury human ethics committee approved the experiment.

Materials

The experiment utilised three different tasks which participants were required to estimate the completion duration, and three different temporal boundary scenarios. The three to-be-completed tasks were:

- Proofread for spelling mistakes a 13-page company report (A4, typed, and double spaced).
- Using the supplied telephone directory, look up and record 10 different contractors' contact details for eight different types of contractors.
- Entering 10 'bills' (e.g., power bill, phone bill) into an account balance sheet creating a new balance as each bill was entered.

The three temporal boundaries required that each task be completed either before morning tea, before lunch, or by the end of the week. For the first two scenarios the participants were to presume that they had just arrived at work, whereas for the third scenario they were to presume that they had just arrived at work on Monday morning. Based on the completion times of similar/identical tasks in experiments conducted by the author (see Chapter 7) it was known that the average completion time for the longest task used here was about 30 minutes. Therefore it could be safely assumed that all of the boundary scenarios used in the present experiment were remote in nature with none of them 'truly' (based on the actual time it would take them to complete the task) constraining the amount of time a person could potentially allocate to their completion.

All participants were required to estimate completion times for all three of the above tasks. Likewise, for all participants one of the tasks was associated with the 'short' remote boundary scenario, one with the 'medium' remote boundary scenario, and one with the 'long' remote boundary scenario. This combination resulted in three true conditions, consisting of the three combinations of temporal boundary for each task. For instance, in condition one the participant was required to estimate the expected duration of the proofreading task under the shortest remote scenario, in condition two it was the medium one, and condition three it was the most remote temporal scenario (see Appendix 2). However, to control for any potential order effects six versions of each condition were utilised counterbalancing the order of task presentation.

Procedure

Potential participants from stage one psychology laboratories were invited to take part in an experiment requiring them to estimate how long they thought it might take them to complete three office-type tasks. Interested participants were randomly assigned to one of the six counterbalanced versions of the three conditions outlined above. Each received a self-explanatory questionnaire outlining the requirement to estimate how long they thought it would take them to complete the tasks described (see Appendix 2). The written instructions were:

> *You are invited to take part in a research project looking into time management in the workplace. The aim of the study is to understand and ultimately reduce the 'time stress' inherent in many jobs. Your participation will involve responding to three work scenarios and providing estimates of how long you think they will take you. Although there is no time limit, this process should take you less than five minutes to complete.*

A space was provided after each written description of a task in which to enter their estimation. Participants made their three estimates in class time. After completion participants were debriefed and thanked for their participation.

Results

Table 2 below shows the estimated times for completing the three tasks under the three different temporal boundary scenarios. The numerical columns show the mean estimated duration (and standard deviations), median estimated durations, and range of estimated durations respectively for each of the three tasks under each of the three temporal boundary scenarios. As can be seen there is a general trend for more time to be allocated to the completion of the task as the temporal boundary becomes more remote. The most pronounce differences in expected duration across all three tasks appear to be between the most remote temporal boundary scenario and the two shorter temporal boundary scenarios.

Table 2. The effect of varying remote temporal boundary scenarios had on expected duration estimation

Task	Temporal Boundary Scenario	Mean Estimated Time (&SDs) to Complete (minutes)	Median Estimated Time to Complete (minutes)	Range of Estimated Times to Complete (minutes)
Proof-read	Morning tea (condition 1)	60.07 (32.65)	60	10 – 150
	Lunch time (condition 3)	70.67 (50.52))	60	15 – 270
	End of week (condition 2)	81.78 (65.77)	70	15 – 360
Contact lookup	Morning tea (condition 2)	76.11 (45.65)	60	5 – 90
	Lunch time (condition 1)	81.00 (57.16)	60	15 - 120
	End of week (condition 3)	115.56 (125.21)	90	20 - 150
Balance	Morning tea (condition 3)	40.78 (35.92)	30	5 – 120
	Lunch time (condition 2)	43.78 (26.00)	30	5 -190
	End of week (condition 1)	86.22 (102.14)	60	8 – 600

A 3x3 mixed design ANOVA, with the combination of task and temporal boundary being the between subject variable and the duration estimates for the three tasks being the within subject variables, was conducted to see whether the differences were significant. The ANOVA revealed no main effect for group/condition (F (2, 132) = .52, p=.60). This result demonstrated that the three groups do not differ significantly as far as the amount of time they estimated it would take to complete the three tasks (given the crossover nature of the experimental manipulation this is the expected result). It revealed a significant main effect for the task variable (F (2, 264) = 10.4, p=.0001), which suggests that there was a significant difference between the three tasks in respect to the amount of time participants allocated for their completion.

This result is not unexpected as no predictions were made concerning the temporal equivalence of the three tasks.

More importantly, as expected, the ANOVA revealed a significant interaction between the group and task variables ($F\ (4, 264) = 6.87$, $p=.0001$). Specifically, planned comparisons revealed significant differences between temporal boundaries. In respect of the proofreading task a significant difference was found between the morning tea temporal boundary and the end of the week temporal boundary ($F\ (1, 132) = 4.00$, $p= 0.047$). Although in the right directions, the differences between the temporal boundaries of morning tea and lunchtime, and lunchtime and the end of the week did not reach significance. In respect of the contact lookup task a significant difference was found between the lunchtime and the end of the week temporal boundary ($F\ (1, 132) = 3.83$, $p= 0.05$) and the morning tea and the end of the week temporal boundary ($F\ (1, 132) = 4.99$, $p= 0.027$). Although in the right direction the difference between the temporal boundaries of morning tea and lunchtime did not reach significance for the contact lookup task. Lastly, with respect to the balance sheet task, a significant difference was found between the lunchtime and the end of the week temporal boundary ($F\ (1, 132) = 9.81$, $p= 0.002$) and the morning tea and the end of the week temporal boundary ($F\ (1, 132) = 11.24$, $p= 0.001$). Again, although in the right direction the difference between the temporal boundaries of morning tea and lunchtime did not reach significance for the balance sheet task. Taken together these results suggest that varying the remoteness of the temporal boundary had a significant effect on expected duration estimation.

Discussion

The present experiment provides support for the hypothesis that remote temporal boundaries have an effect on expected duration estimation. Support was found for the view that the more remote the temporal boundary, the more time participants will allocate to the completion of the task. Participants allocated significantly more time to the completion of all three tasks under the end-of-week temporal boundary scenario, compared to the morning tea scenario. Further, for two of the three tasks participants allocated significantly more time to the end-of-week scenario than the lunchtime scenario.

Although this is probably one of the first experiments that specifically deals with the potential positive effects (in that they potentially reduce the degree of overestimation of task completion times) of temporal boundaries in making accurate expected duration estimates, other expected duration estimation research can be interpreted in this way providing further support for the stance put forward here. For example, it is argued that Burt and Forsyth's (1999) scheduler segmentation experiment discussed earlier can be viewed as demonstrating the importance of providing appropriate temporal boundaries, whereby segmentation matched to the actual duration of the task resulted in more accurate estimates than either a blank scheduler (no temporal boundary cue) or one providing too large a segmentation (an inappropriate temporal boundary cue).

As mentioned earlier, most research concerning the effect of bounding appears to suggest that it hinders accuracy. However, the present findings suggest otherwise in that it appears even remote temporal boundaries can be useful in directing/constraining a persons' expected duration estimation.

Chapter 7

Experiments 3 & 4: The effect of estimation rounding and preference for reporting estimates in the form of prototypical temporal values

Chapter 7 is comprised of two experiments. In relation to the 'expected process' component of my model of expected duration estimation (see Figure 4) discussed in section 4.6, it is argued that when a person is required to make an expected duration estimate they tend to round their estimate, often to the form of a prototypical temporal value. Experiments 3 and 4 are primarily concerned with the effect the rounding of expected durations to prototypical temporal values has on the accuracy of these estimates.

7.1 Experiment 3: Chunking relatively short duration tasks together as a strategy to increase scheduling accuracy

Introduction

Experiment 3 was designed to test some of the predictions concerning the rounding of expected duration estimates to prototypical temporal values as outlined in section 4.6 above. Firstly, based on the findings outlined in that section, it appears when faced with relatively short duration tasks (minutes rather than days) people tend to overestimate task completion times. Specifically, the present experiment will seek to test:

Hypothesis 1: When asked to schedule the completion of relatively short duration tasks (2 – 8 minutes) participants will tend to overestimate the time required for their completion.

Secondly, it is suggested that based on the pattern of estimates reported in previous expected duration and autobiographical studies (e.g., Forsyth, 1998; Huttenlocher et al., 1990), when asked to estimate the duration of an upcoming event/task a person is likely to round that estimate to a prototypical temporal value. Specifically:

Hypothesis 2a: When asked to estimate the duration of a to-be-completed task participants will be more likely to provide an estimation which is in the form of a prototypical temporal value (e.g., five-minute 'chunks') than a non-prototypical temporal value (e.g., one, two, or three minutes).

Further, one of the likely indictors of the tendency to report prototypical temporal values is that there will be an inverse relationship between actual (& presumably estimated) duration and the coefficient of variability of the estimated duration. This relationship is expected to occur due to the magnitude differences in actual duration of tasks around five minutes and ones around 15-20 minutes, and the nature of the coefficient of variability statistic. Because of the tendency to estimate prototypical temporal values, where there is inter-subject variability of relatively short duration task estimates, that variation will be of a larger magnitude than for longer tasks. For example, the 'available' (assuming people will tend to report common prototypical temporal values) variation for a relatively short duration task, which will typically be estimated as taking five minutes, will tend to be 10 minutes (i.e., twice as long). Alternatively, longer tasks have more fine-grain (relatively speaking) variations available to participants. For instance, if the actual duration is around 10 minutes a person trying to accurately estimate its duration can potentially choose (again assuming they will tend to favour prototypical temporal values) estimates of five, 10, or 15 minutes. These 'available' variations represent a lower magnitude of variation than in the five-minute example.

Hypothesis 2b: As a result of the tendency to report prototypical temporal values there will be an inverse relationship between actual (& estimated) duration and the coefficient of variability of the estimated duration.

Thirdly, although such rounding and the associated over-reliance on prototypical temporal values will tend to lead to inaccuracies for almost all expected duration estimates, it is argued that this tendency to separate time into five-minute segments will result in greater inaccuracy (increased duration overestimation) for shorter duration tasks. An inverse relationship between actual task duration and task duration overestimation will occur, because as the actual task duration increases, the five-minute segmentation (rounding) becomes less detrimental to accuracy. For example, under this segmentation a task with an actual duration of 1½ minutes will have an estimated completion duration of five-minutes (an overestimation of 333%) whereas for tasks of a greater actual duration the five-minute segmentation becomes proportionally less detrimental. In support of this assertion Forsyth (1998) found a significant inverse relationship between objective task duration and overestimation.

In light of this finding it is predicted that grouping relatively short duration tasks (between three - eight minutes) together will result in greater task duration estimation accuracy. Experiment 3 evaluated this proposition by encouraging participants to group some relatively short duration tasks together while scheduling and completing others individually. Specifically:

Hypothesis 3: Grouping relatively short duration tasks (between three - eight minutes) together for scheduling purposes will result in less time being allocated to their completion than if the same task were scheduled separately.

Method

Experiment design overview

The experiment consisted of two participant conditions, with both between and within condition variables. Both conditions involved the scheduling and completion of the same six office-type tasks. In condition one the description of the last three tasks were chunked together to form 'one' task. In condition two it was the description of the first three tasks that were chunked together to form 'one' task. These manipulations resulted in both groups scheduling and completing 'four' tasks. The main manipulation was whether tasks had or had not been chunked together for scheduling purposes.

Participants

A group of people comprised of 20 males and 20 females; with a mean age of 22.5 years, undertaking a variety of studies within the University of Canterbury participated in this experiment (none had participated in any of the three other experiments). A power analysis was conducted which suggested that based on finding a relatively large effect, 40 was a suitably large sample to make a type II error unlikely. Participants were recruited through the local Student Job Search. They received NZ$20 remuneration for participating in this experiment (a level similar to that expected in an office workplace environment). This remuneration was deemed an important part of the experiment by helping to provide similar real-world motivational levels and generally increasing the external validity of the findings. The University of Canterbury human ethics committee approved the experiment.

Materials

Daily planner

The daily planner consisted of an A4 sheet of paper with a plain border headed up 'Daily Planner' (see Appendix 3).

Activities

Participants were required to complete four different 'tasks'. One of the four 'tasks' in each of the two conditions had three sub-components, which resulted in six tasks being utilised in this experiment. Two criteria were used in the selection of these tasks. Firstly, a balance was sought between creating a verisimilitude of an office environment, and having tasks that all participants wouldfind at least somewhat familiar, and most importantly, possible to complete. Secondly, individual tasks were designed (based on previous research and informal pilot studies) so as to have a relatively short average completion time (between three - eight minutes), with most having an average completion duration of less than five minutes. Additionally, for purposes of being able to compare estimates both across and within subjects, an effort was made to match tasks on average completion times, resulting in three pairs of tasks. The ability to make within subject comparisons was deemed an important part of this experiment. This is because, as Zakay (1990) points out, averaging duration estimates across subjects and comparing group data can potentially be misleading. Although it is typically impossible to undertake a within-subjects design when using the retrospective paradigm (Zakay, 1990), the present expected duration estimation situation potentially (as long as the pairing of tasks on actual duration was successful) enables some with-in subject comparisons to be made so strengthening any findings.

The three pairs of tasks consisted of:

Pair one

Task 1: Proofreading a three-page document for spelling mistakes.

Task 4: Entering five 'bills' (e.g., power bill, phone bill) into an account balance sheet, creating a new balance as each bill is entered.

Pair two

Task 2: Delivering eight preaddressed letters to their respective pigeonholes on another floor in the same building.

Task 5: Purchasing a candy bar from the vending machine in a nearby building.

Pair three

Task 3: Telephoning an automated river report to obtain current fishing conditions for four local rivers.

Task 6: Alphabetising 20 job applications in respect to the applicant's surname.

Participants received a complete description of what the task involved, including all the required materials for their completion (e.g., money to make the candy bar purchase). Outlined below is the full description that the participants received for each of the six tasks:

Task 1

A three-page document, typed (double spaced) on A4 paper is provided. Your task is to proof read it for spelling mistakes. Circle each spelling mistake that you find.

Task 2

Deliver eight letters to their respective pigeonholes. The addressee's pigeonholes are located in Room 209 of the psychology building (i.e., the Resource room). This room is basically two floors directly below your present location (opposite the secretaries' office).

Task 3

Obtain the current river conditions (water colour & fish-ability) for the following four Canterbury rivers: Waimakariri river (at the mouth), Rakaia river (at the mouth), Hurunui river, and Waiau river. To gain this information you will need to phone Fish and Game North Canterbury's automated river report. The phone number should be looked up in the telephone book provided.

Task 4

Five 'bills' (e.g., power bill, phone bill) are provided, along with an account balance sheet. Your task is to enter the 'billed amount' in the debt column and subtract the amount from the balance, creating a new balance after each subtraction (pen and paper subtraction - no calculator).

Task 5

Buy a candy bar (or similar) from the vending machine just inside the law café (if you look out the window you will see the new law building – the café is located near the main entrance on the ground floor). One dollar is in the appropriate folder.

Task 6

Arrange 20 job applications in alphabetic order with respect to the applicants' surnames (i.e. 'A' in the front, through to 'Z' at the back).

Procedure

As noted above in section 4.1 one of the biggest problems when trying to interpret the findings of many expected duration estimation studies is the fact that, because of experimental conditions, participants are often hypo-vigilant towards temporal issues and time management in general. The present experiment attempted to overcome this problem by promoting the experiment as being primarily interested in job satisfaction in office work. In addition, no one was required to remove watches (so as to reduce their focus on temporal matters) and at no time were participants aware that their progress was being timed. Furthermore, participants were not required to complete any temporally related psychometric scales.

Finally, many studies require participants to provide expected duration estimates in seconds or minutes. However, it is argued that this is not a typical situation in real-world duration estimation, and that it leads participants to be overly aware of temporal aspects of the experiment. Another reason not to constrain the scale of response is so that the expected duration estimation is not overly restrained by providing a cue concerning the possible duration of the task (Huttenlocher et al., 1990). For these reasons participants were not constrained to provide duration estimates in any particular scale/magnitude (i.e., minutes versus seconds).

It should be pointed out that potentially important variables could be assumed to be controlled for (e.g., education, IQ, age, and gender) by the randomisation process outlined below.

Participants were randomly assigned to two conditions. In the first condition (group 1) tasks four, five, and six were grouped together as a single 'task' whereas tasks one, two, and three were presented separately thus resulting in four to-be-scheduled and completed tasks. In condition two (group 2) tasks one, two, and three were grouped together while tasks four, five, and six were presented separately, again resulting in four to-be-scheduled and completed tasks. Descriptions of the individual tasks, and their order of presentation, were identical for both conditions. The only difference between the two conditions was that either the first three or last three tasks were introduced as a single to-be-scheduled and completed 'task'. Below are the 'four' tasks, as introduced to the participants, in condition one and condition two.

Condition one:

"**TASK 1**

- A three-page document, typed (double spaced) on A4 paper is provided. Your task is to proofread it for spelling mistakes. Circle each spelling mistake that you find. *When completed place the materials back in the folder and place the folder in the completed task tray.*

TASK 2

- Deliver eight letters to their respective pigeonholes. The addressee's pigeonholes are located in **Room 209** of the psychology building (i.e., the Resource room). This room is basically two floors directly below your present location (opposite the secretaries' office). *When completed place the folder in the completed task tray.*

TASK 3

- Obtain the current river conditions (water colour & fish-ability) for the following four Canterbury rivers: Waimakariri river (at the mouth), Rakaia river (at the mouth), Hurunui river, and Waiau river. To gain this information you will need to phone **Fish and Game North Canterbury's automated river report**. The phone number should be looked up in the telephone book provided. *When completed place the materials back in the folder and place the folder in the completed task tray.*

TASK 4

- Five 'bills' (e.g., power bill, phone bill) are provided, along with an account balance sheet. Your task is to enter the 'billed amount' in the debt column and subtract the amount from the balance, creating a new balance after each subtraction (pen and paper subtraction - no calculator).

- Buy a candy bar (or similar) from the vending machine just inside the law café (if you look out the window you will see the new law building – the café is located near the main entrance on the ground floor). One dollar is in the appropriate folder.
- Arrange 20 job applications in alphabetical order with respect to the applicants' surnames (i.e. 'A' in the front, through to 'Z' at the back). *When completed place the materials back in the folder and place the folder in the completed task tray."*

Condition two:

"**TASK 1**

- A three-page document, typed (double spaced) on A4 paper is provided. Your task is to proof read it for spelling mistakes. Circle each spelling mistake that you find.
- Deliver eight letters to their respective pigeonholes. The addressee's pigeonholes are located in **Room 209** of the psychology building (i.e., the Resource room). This room is basically two floors directly below your present location (opposite the secretaries' office).
- Obtain the current river conditions (water colour & fish-ability) for the following four Canterbury rivers: Waimakariri river (at the mouth), Rakaia river (at the mouth), Hurunui river, and Waiau river. To gain this information you will need to phone **Fish and Game North Canterbury's automated river report**. The phone number should be looked up in the telephone book provided. *When completed place the materials back in the folder and place the folder in the completed task tray.*

TASK 2

- Five 'bills' (e.g., power bill, phone bill) are provided, along with an account balance sheet. Your task is to enter the 'billed amount' in the debt column and subtract the amount from the balance, creating a new balance after each subtraction (pen and paper subtraction - no calculator). *When completed place the materials back in the folder and place the folder in the completed task tray.*

TASK 3

- Buy a candy bar (or similar) from the vending machine just inside the law café (if you look out the window you will see the new law building – the café is located near the main entrance on the ground floor). One dollar is in the appropriate folder. *When completed place the materials back in the folder and place the folder in the completed task tray.*

TASK 4

- Arrange 20 job applications in alphabetical order with respect to the applicants' surnames (i.e. 'A' in the front, through to 'Z' at the back). *When completed place the materials back in the folder and place the folder in the completed task tray."*

Task scheduling and completion

Participants were seated individually at a cubicle (up to four participants completed the experiment at any one time) which contained: a table, experimental instructions, task activity descriptions, a daily planner, four folders containing the task material, a telephone and directory, and a 'Completed Task' tray.

Upon being seated each participant was instructed to read the following instructions, which were placed in front of them:

> *"This experiment examines job satisfaction in office work. You are required to complete four tasks (some tasks may have a number of separate components). These tasks can be carried out in any order you choose, however you must complete one task before you move on to the next one. Try to imagine that you are working in an office situation and the completion of these tasks is part of your duties. A researcher will be present during the experiment - please try to ignore their presence.*
>
> ***Specifically you are required to:***
>
> 1. ***Read the accompanying sheet that describes the tasks.***
> 2. ***Plan the completion of the four tasks using the accompanying 'daily planner'.*** *Enter each task onto the planner in the order you propose to complete them, along with the* <u>*time you expect to need*</u> *for their completion. Tasks must be scheduled one after the other. Please do this now.*
> 3. ***Upon completion of the planning please begin completing the tasks in the order you have chosen.***
>
> *- if you have any questions please ask the researcher* <u>*now*</u>*."*

As can be seen from the instructions above, as soon as the participant had completed the scheduling of the four tasks they were free to start completing them in the sequential order they had chosen. The researcher, who was partitioned off from the participant completing the experiment (in a raised cubical in which the experimenter had a clear view of the participants), discretely recorded the time taken for the participant to complete each task. Upon completion participants were paid, debriefed, and thanked for their participation.

Results and Discussion

Hypothesis 1: The tendency to overestimate actual duration

To answer the question – 'do people tend to overestimate the time required to complete relatively short duration tasks?' - the data was examined to determine the degree to which participants were able to estimate how long it would take to complete the three tasks which they where presented individually (as opposed to the three that were chunked together as 'one task'). Due to the crossover design used in this experiment only half of the participants provided individual time estimates for any particular task. The first and second numerical columns in Table 3 show the mean actual and estimated times for the completion of each task. As can be seen, the mean durations for completing the six tasks ranged from just over three minutes (191 seconds - order documents) to around seven minutes (420 seconds - proofreading & 423 seconds - balance sheet tasks). In addition, these two columns showed that the mean estimated times tended to be longer than the mean actual times to complete the 6 tasks.

Numerical column number three in Table 3 shows the coefficient of variation, which is the standard deviation divided by the mean estimation (standard deviations cannot simply compared as they typically increase as actual/estimated duration increases). This is an underutilised statistic that can often provide valuable information concerning duration estimates (Block & Zakay, 1997; Block et al., 1999). It enables the direct comparison of variability across conditions. This coefficient of variation data is discussed below under hypothesis 2b.

The fourth numerical column in Table 3 shows the mean signed error (estimated minus actual duration) for each task. As can be seen from column four of Table 3 the mean signed error was positive for all six tasks, meaning that participants tended to overestimate the amount of time they would actually need to complete each task. The fifth (second to last) numerical column in Table 3 displays this signed error as a proportion of the actual time taken. This figure was derived by calculating what percentage the mean signed error is of the actual time taken (numerical column one). This percentage of error (in this case overestimation) shows that, at least in the case of the present tasks, a greater degree of overestimation was associated with shorter duration tasks (e.g., the river report and the ordering of the documents).

Francis-Smythe and Robertson (1999) have commented that although studies like that by Burt and Kemp (1994) report a trend towards overestimation it may be caused by just a few people vastly overestimating the duration. However, no support for this claim was found in the present experiment. As can be seen in the last column of Table 3 the majority of participants provided overestimates for each of the tasks (except the balance task).

Table 3. Summary of task duration estimation accuracy.

		Mean Time (&SDs) to Complete (Seconds)	Mean Estimated Time (&SDs) to Complete (Seconds)	Coefficient of Variation of Estimated Durations	Signed Error (Estimated – Actual Time)	Mean Difference as a Proportion of Actual Time Taken	Proportion of Participants Who Overestimated Actual Duration
Group 1 data n=20	1. Proof Reading	420 (101)	498 (297)	0.596	+78	19%	60%
	2. Deliver letters	252 (75)	402 (133)	0.331	+150	60%	100%
	3. River reports	234 (67)	546 (286)	0.524	+312	134%	90%
Group 2 data n=20	4. Balance Sheet	423 (148)	483 (385)	0.793	+50	12%	45%
	5. Candy Bar	285 (62)	451 (289)	0.641	+166	58%	75%
	6. Order Documents	191 (59)	393 (257)	0.654	+202	106%	95%
	All Six Tasks	1808 (188)	2773 (974)	0.352	+965	53%	

If the various actual and estimated durations shown in the first and second numerical columns of Table 3 are compared, it appears that the general trend of the overestimates is that the shorter the task the greater the average overestimation and the higher the proportions of individual participants providing overestimates (the last column of Table 3). It is worth noting that the degree of overestimation found with the river condition task (134%) maybe somewhat inflated due to the relative unfamiliarity of the task, however it is argued that the remaining five tasks were equally familiar to participants from a western university. Therefore, an unfamiliarity explanation does not explain why mean overestimates of the document ordering task, which should have been a familiar task for the participants to complete, was so high (106%).

Unlike previous research, which has suggested that overestimates found in expected duration studies using relatively short duration tasks are due to a 'safe estimation strategy' (Robinson, 1992), it is argued that this overestimation is primarily due to, or at the very least substantially effected by, 'rounding' or in the language used by Huttenlocher, Hedges, and Bradburn (1990) 'a local bias in the regions around prototypic values' – in this case five minutes (similar to Burt and Forsyth (1999) and Forsyth (1998) less than one per cent of estimated durations were outside of five-minute intervals). For example, the three tasks (letter delivery, river conditions, and document ordering) with the shortest average durations (around three to four minutes) also have the highest proportions of participants providing overestimates (100, 90, and 95% respectively). As the predominant 'natural' prototypic value for this scale of duration estimation appears to be five minutes, participants tend to be 'forced' to overestimate the duration of these tasks.

Conversely, at the other end of the continuum, the two tasks with the longest average actual duration (proofreading and balancing bills) of around seven minutes had the lowest proportions of participants providing overestimates (60 and 45% respectively). Accepting that the prototypical value for these tasks is five minutes (see hypothesis 2a & 2b below), participants striving for accuracy had a choice between allotting five (an underestimation) or 10 (an overestimation) minutes to the tasks - a choice which is reflected in the proportion of over and underestimates for these two tasks (see Figure 6).

Hypothesis 2 a & b: The tendency to report prototypical temporal values

It was suggested that when asked to estimate the duration of a to-be-completed task participants would be more likely to provide an estimation which is in the form of a prototypical temporal value (e.g., five minutes) than a non-prototypical temporal value (e.g., one, two, or three minutes). An informative way to display each of the four duration estimates the 40 participants' supplied (i.e., a total of 160 estimates) is to tabulate all actual durations against all estimated durations. As can be seen in Figure 6, although actual task durations (both grouped and individual) are spread along the temporal continuum (far right-hand column), estimates tend to be predominately prototypical temporal values ('shaded' vertical columns) – specifically in the present case multiples of five-minutes.

Specifically in relation to the hypothesis put forward, the majority (73%) of the 160 estimates, which participants supplied, appear to be prototypical temporal values (multiples of five minutes), and furthermore, 51 per cent of all estimates were either five- or 10-minutes. Although it could be argued that some of these five-minute interval estimates do not represent prototypical temporal values (i.e. the estimates represent five individual minutes rather than one or two larger 'five-minute' chunks), given the irregular nature of the actual task duration (see right-hand column of Figure 6) this interpretation cannot explain the overwhelming tendency to report estimates in multiples of five-minutes.

Estimated duration to the nearest minute

Actual duration to the nearest minute (rows); Cumulative total of the number of completion times for each respective duration (last column)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	
1																																									0
2		1			3		1	1		1										1																					8
3			3	3	17	1	1	2	1	8										3																					39
4				1	8	1	2			3					2			1																							18
5		1	1		8	1	2			5					1																										19
6					6		3	1		1					1			1																							13
7			3		2			1		4																															10
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	0	2	7	4	49	4	10	5	1	32	0	3	2	0	18	0	0	2	1	13	0	0	0	0	2	0	0	0	0	4	0	0	0	0	0	0	0	0	0	1	160

Cumulative total of the number of estimates for each respective duration

Figure 6. A tabulation of all actual durations against estimated durations

Further, it was predicted that one of the likely indictors of the tendency to report prototypical temporal values would be that there would be an inverse relationship between actual (& presumably estimated) duration and the coefficient of variability of the estimated duration. A significant (negative) Spearman rank order correlation of -.25 ($p < .05$) was found between the coefficient of variability of estimated durations and the actual durations of these estimates ($n=160$). Similarly, a significant (negative) Spearman rank order correlation of -.37 ($p < .05$) was found between the coefficient of variability of estimated durations and the relevant estimated durations ($n=160$). These findings provide support for the view that shorter tasks are associated with more variable estimates than relatively longer ones.

Hypothesis 3: Evaluation of task grouping strategy

As has been mentioned, in order to investigate whether the grouping of short tasks together can increase duration estimation accuracy, half of the six tasks were 'chunked' (grouped) together and presented as one task (the last three for group 1 and the first three for group 2). Firstly it needs to be shown that there were no significant completion time differences between the groups.

The first numerical column of Table 4 shows the mean actual duration it took participants to complete the first three, second three, and all six tasks. A 2x2 mixed design ANOVA, with group being the between subject variable and whether the tasks were chunked together or not being the within subject variable, was conducted for the actual task durations. It revealed no main effect for group ($F(1, 38) = 1.53$, $p=.22$). This result confirms that the two groups do not differ significantly as far as the overall duration it took to complete all six tasks. In addition, it revealed no main effect for the chunking variable ($F\ (1, 38) = 1.46$, $p=.23$). Likewise, the ANOVA revealed no significant interaction between the group and chunking variables ($F\ (1, 38) = .15$, $p=.70$). Taken together these three results suggest that there was no significant difference between the average completion durations of the first three and second three tasks. The result confirms the balancing of actual task duration for the first and second groups of three tasks (three pairs – see Materials section) had been successful. This non-significant difference means that analysis of the effect chunking these tasks together has on duration estimation accuracy can be conducted both within and across the two groups of participants. In addition, although not expected, this finding also suggests that chunking relatively short duration tasks together has no significant positive (or negative) effects on actual completion durations.

Table 4. Duration estimation accuracy data comparing chunked and non-chunked tasks.

			Mean Time (&SDs) to Complete (Seconds)	Mean {& median} Estimated Time (&SDs) to Complete (Seconds)	Coefficient of Variation of Estimated Durations	Signed Error (Estimated – Actual Time)	Mean Difference as a Proportion of Actual Time Taken
Group 1	Presented separately	1. Proofreading, 2. Deliver Letters, 3. River Reports	907 (105)	1446 {1440} (496)	0.343	+539	59%
	Grouped together	4. Balance Sheet, 5. Candy Bar, 6. Order Documents	770 (132)	1077 {900} (428)	0.397	+307	40%
		All six tasks	**1678 (132)**	**2523 (821)**	**0.325**	**+845**	**50%**
Group 2	Grouped together	1. Proofreading, 2. Deliver Letters, 3. River Reports	874 (182)	966 {900} (360)	0.373	+92	11%
	Presented separately	4. Balance Sheet, 5. Candy Bar, 6. Order Documents	727 (151)	1327 {1170} (844)	0.636	+600	83%
		All six tasks	**1601 (232)**	**2293 (1130)**	**0.493**	**+692**	**43%**

Turning now to the main question at hand – the effect of task chunking on expected duration estimation accuracy - numerical column two of Table 4 shows the mean estimated durations for the two conditions of each group. These means appear to demonstrate that chunking tasks together has had the effect of reducing overestimation of actual task durations. This is further backed up by the signed error (estimated duration – actual duration) data displayed in the fourth numerical column of Table 4. A similar trend is evident in the last column of Table 4 where this information is displayed as 'mean difference as a proportion of actual time taken'. Whereas presenting the first three tasks (proofreading, letter delivering, river reports) separately resulted in a mean overestimation of 59 per cent, presenting the same tasks grouped together resulted in a mean overestimation of only 11 per cent. Similarly, presenting the second three tasks (balancing the books, making a purchase, ordering documents) separately resulted in a mean overestimation of 83 per cent, whereas presenting the same tasks grouped together resulted in an mean overestimation of only 40 per cent.

A 2x2 mixed design ANOVA, with group (condition) being the between subject variable and whether the tasks were chunked together or not being the within subject variable, was conducted for estimated task durations (see Figure 7.). It revealed no main effect for group ($F(1,38) = .54$, $p=.47$). This result confirms that the two groups did not differ significantly as far as the overall duration estimated to complete all six tasks. In addition, it revealed no main effect of chunking ($F(1,38) = .00$, $p=.96$), which was expected due to the crossover nature of the experimental design (for group one the second three tasks were chunked together whereas for group two it was the first three). However, as expected, the ANOVA revealed a significant interaction between the group and chunking variables ($F(1,38) = 17.91$, $p=.0001$).

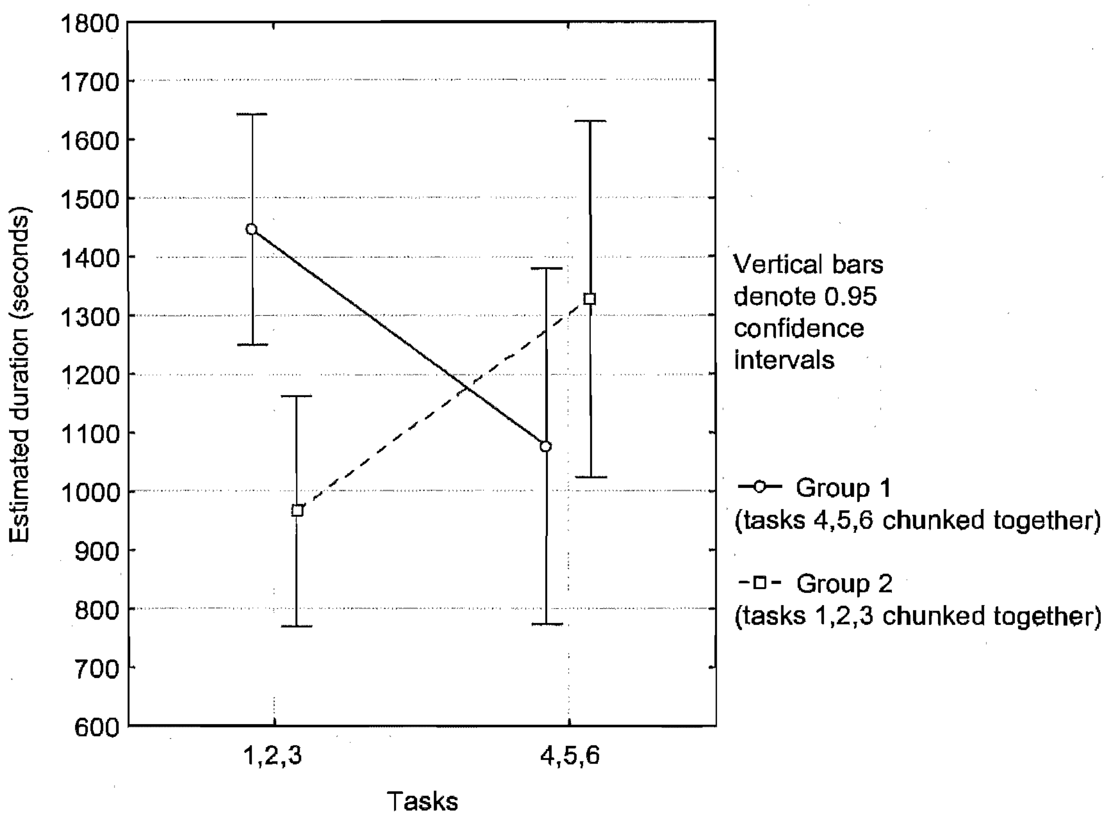

Figure 7. A graphical representation of the relationship between the two groups and chunked vs. non-chunked tasks.

More specifically, planned comparisons revealed significant differences between the two groups on their duration estimates for tasks one, two, and three ($F(1,38) = 12.27$, $p=.001$), group one's estimation of tasks one, two, and three and tasks four, five, and six ($F(1,38) = 9.15$, $p=.004$) and similarly group two's estimation of tasks one, two, and three and tasks four, five, and six ($F(1,38) = 8.76$, $p=.005$). Although in the right direction, the only comparison where a significant difference was not found was between the two groups and tasks four, five, and six ($F(1,38) = 1.39$, $p= .25$). A possible reason why this comparison did not reach significance may have been due to the relatively large amount of variation evident in the estimates group one provided for tasks four, five, and six.

These results support the hypothesis put forward in the introduction that grouping relatively short duration tasks together results in less time being allocated to them and, in this case, more accurate estimates. It is argued that the reason for this is similar to the reason outlined above whereby shorter individual tasks were overestimated to a larger extent more often than longer ones. Specifically, as discussed earlier in the present experiment it is argued that the predominant prototypical temporal value is five minutes. Due to the fact that most of the six individual tasks have an average actual duration of less than five minutes participants will tend to be 'forced' to allocate the minimum feasible duration to their completion (i.e., five minutes) – resulting in very large overestimates for the shorter duration tasks (i.e., ordering documents and river reports). Alternatively, when presented with the three tasks grouped together, because of the substantially longer actual duration the same prototypical temporal value of five minutes enables a more fine-grained estimation than it did for the individual tasks. So rather than being forced to allocate 15 minutes (which is the case when they allocate time for the three individual tasks – three lots of five) they may decide to allocate 10 minutes instead. It is important to point out that it is not being suggested that all people will behave in this way when presented with a similar problem, only there is a predisposition for this to occur.

Summary of Experiment 3

The results provide support for the view that people tend to overestimate the durations of relatively short duration tasks. Additionally, it is argued that the pattern of individual overestimation is primarily due to the effect of a local bias in the regions around the prototypic temporal value – in this case five-minute chunks.

Further, the results appear to suggest that chunking short duration tasks together results in less time being allocated to their completion and therefore increased duration estimation accuracy. The suggested reason for this increase in estimation accuracy is the predisposition participants had to providing estimates that were in multiples of five minutes. As explained above, this predisposition means that inaccuracies are likely to be greater, the shorter the actual duration of the task is.

However, although the above findings appear to provide evidence for chunking tasks together for scheduling purposes of relatively short duration tasks (less than five minutes) it is less clear what they mean for longer tasks. For instance, it seems likely that people will change the 'scale' (prototypical value) of their estimation as the actual duration increases. If asked to estimate how long it will take to read a 300-page manuscript it would seem unlikely that the predisposition towards estimates of multiples of five minutes would prevail! This being the case, the effectiveness of chunking tasks together in order to increase accuracy may be dependent on the association between the actual duration of the task and the prominent prototypical temporal value chosen. This association will be investigated in Experiment 4.

7.2 Experiment 4: Chunking relatively long duration tasks (20-30 minutes) together as a strategy to increase scheduling accuracy

Introduction

Experiment 4 extends the generalisability of the findings from Experiment 3 by assessing the effect chunking tasks together for scheduling purposes has on duration estimation accuracy in tasks of around 20-30 minutes each. The following four hypotheses will be tested:

Hypothesis 1: When asked to schedule the completion of tasks ranging from 20-40 minutes participants will tend to overestimate the time required for their completion.

Hypothesis 2a: When asked to estimate the duration of a to-be-completed task participants will be more likely to provide an estimation which is in the form of a prototypical temporal value (e.g., five-minute 'chunks') than a non-prototypical temporal value (e.g., one, two, or three minutes).

Hypothesis 2b: As a result of the tendency to report prototypical temporal values there will be an inverse relationship between actual (& estimated) duration and the coefficient of variability of the estimated duration.

Hypothesis 3: Grouping tasks with an average individual duration of 20 – 40 minutes together for scheduling purposes will result in less time being allocated to their completion (and therefore as a result of hypothesis 1, more accurate estimates) than if the same task were scheduled separately.

Method

Experiment design overview

The experiment design was identical to that used in Experiment 3.

Participants

Forty participants, 19 males and 21 females; with a mean age of 22.4 years, undertaking a variety of studies within the University of Canterbury participated in this experiment (none had participated in any of the three other experiments). Like Experiment 3, participants were remunerated for taking part in this experiment at a level similar to that expected in a workplace environment (NZ$30). The University of Canterbury human ethics committee approved the experiment.

Materials

Daily planner

As in Experiment 3 the daily planner consisted of an A4 sheet of paper with a plain border headed up 'Daily Planner' (see Appendix 3).

Activities

Participants were required to complete four 'tasks'. One of the four 'tasks' in each of the two conditions had three sub-components, which resulted in six tasks being utilised in this experiment. Two criteria were used in the selection of these tasks. As with Experiment 3, a balance was sought between creating a verisimilitude of an office environment, and having tasks that all participants would find at least somewhat familiar and possible to complete. Secondly, individual tasks were designed so as to have a significantly longer average completion time than those used in Experiment 3. This was achieved by either increasing the magnitude of some of the tasks used in Experiment 3 or by designing new tasks that were trialled by volunteers and adjusted accordingly. Tasks with an average completion time of between 20-40 minutes were created. Similar to Experiment 3, an effort was made to match tasks on average completion times resulting in three pairs of tasks. As in Experiment 3 it was hoped that there would be no significant difference between the actual time it takes to complete the first three and the second three tasks. Although half of the tasks from Experiment 3 were retained in an extended form, three completely new tasks were designed for this experiment to help extend the external validity of the findings. The three pairs of tasks consisted of:

Pair one

Task 1: Proofreading a 13-page document for spelling mistakes.

Task 4: Entering 20 'bills' (e.g., power bill, phone bill) into an account balance sheet creating a new balance as each bill is entered.

Pair two

Task 2: Writing a two-page report concerning the participants' Christmas holidays for a consumer research company.

Task 5: Ordering 100 job applications with respect to the year they were received then alphabetised in respect to the applicant's surname (within that particular year).

Pair three

Task 3: Looking up (using a telephone book) and recording the contact details for 10 different contractors for eight different types of contracting work.

Task 6: Going to the campus library and retrieving subscription information on 11 journals.

Participants received a complete description of what the task involved along with 'credible' justification (where required – see below) for the tasks' completion. All materials for completion of the tasks were provided to the participant (e.g., paper, pens, 'forms' in which to enter specified information, & phone book). Outlined below is the full description, as given to the participant, of the six tasks:

TASK 1

A 13-page company report, typed (double spaced) on A4 paper is provided. Your task is to proofread it for spelling mistakes. Circle each spelling mistake that you find.

TASK 2

The consumer research company you work for is currently interested in how people spend their holiday time. As part of this information gathering process you are required to write a two-page document describing what you did during the Christmas holidays.

TASK 3

The company you work for is thinking of building or renting a new office. As part of this process they want to get quotes from relevant providers. Using the telephone book (yellow pages) provided look-up and record the names and phone numbers (response forms provided) of:

10 Builders	*10 Plumbers*
10 Real Estate Agents	*10 Concrete workers*
10 Civil Engineers	*10 Interior Decorators*
10 Roofing Contractors	*10 Architects*

TASK 4

Twenty 'bills' (e.g., power bill, phone bill) are provided, along with an account balance sheet. Your task is to enter the 'billed amount' in the debt column and *subtract the amount from the balance, creating a new balance after each subtraction (pen and paper subtraction - no calculator).*

TASK 5

The company you work for has many job application letters, which it has received over the past five years. These need to be ordered and filed. The folder contains 100 job application letters. Firstly, you need to sort the letters with respect to the year they were sent. This will result in five groups of letters (1995, 1996, 1997, 1998, and 1999). For each of these five groups you are required to arrange the job applications in alphabetic order with respect to the applicant's surname (i.e. 'A' in the front, through to 'Z' at the back). The paper clips provided should be used to keep each group together.

Task 6

The company you work for is thinking of subscribing to various academic journals. Your task is to gather subscription information on these journals (normally found on the inside front or back cover). Go to the current periodicals section of the main library and record the annual institutional subscription rate (non-airmail where applicable) and the subscription address for the following 10 journals (call numbers provided):

Utilitas	*B 843.A1.U90*	*Journal of Social & Evolutionary Systems*	*GN 301.J91*
Memory	*BF 371.M5339*	*Camera Obscura*	*PN 1995.9.W6.C184*
Infant Behaviour & Development	*BF 723.I6.I439*	*New German Critique*	*PT 1.N535*
Journal of Jewish Studies	*BM 1.J89*	*The Lichenologist*	*QK 581. L700*
Pacific Affairs	*DU 1.P117a*	*Physiological Reviews*	*QP 1.P581*

Procedure

The procedure used in Experiment 4 was identical to Experiment 3 with the exception of the tasks that were completed. Specifically, participants were randomly assigned to one of two conditions. In the first condition (group 1) tasks 4, 5, and 6 were grouped together as a single 'task' whereas tasks 1, 2, and 3 were presented separately thus resulting in four to-be-scheduled and completed tasks. In condition two (group 2) tasks 1, 2, and 3 were grouped together while tasks 4, 5, and 6 were presented separately, again resulting in four to-be-scheduled and completed tasks. Below are the 'four' tasks, as introduced to the participants, in condition one and condition two.

Condition one:

"**TASK 1**

- A 13-page company report, typed (double spaced) on A4 paper is provided. Your task is to proofread it for spelling mistakes. Circle each spelling mistake that you find. *When completed place the materials back in the folder and place the folder in the completed task tray.*

TASK 2

- The consumer research company you work for is currently interested in how people spend their holiday time. As part of this information gathering process you are required to write a two-page document describing what you did during the Christmas holidays. *When completed place the materials back in the folder and place the folder in the completed task tray.*

TASK 3

- The company you work for is thinking of building or renting a new office. As part of this process they want to get quotes from relevant providers. Using the telephone book (yellow pages) provided look-up and record the names and phone numbers (response forms provided) of:

10 Builders	*10 Plumbers*
10 Real Estate Agents	*10 Concrete workers*
10 Civil Engineers	*10 Interior Decorators*
10 Roofing Contractors	*10 Architects*

When completed place the materials back in the folder and place the folder in the completed task tray.

TASK 4

- Twenty 'bills' (e.g., power bill, phone bill) are provided, along with an account balance sheet. Your task is to enter the 'billed amount' in the debt column and subtract the amount from the balance, creating a new balance after each subtraction (pen and paper subtraction - no calculator)..
- The company you work for has many job application letters, which it has received over the past 5 years. These need to be ordered and filed. The folder contains 100 job application letters. Firstly, you need to sort the letters with respect to the year they were sent. This will result in 5 groups of letters (1995, 1996, 1997, 1998, and 1999). For each of these 5 groups you are required to arrange the job applications in alphabetic order with respect to the applicant's surname (i.e. 'A' in the front, through to 'Z' at the back). The paper clips provided should be used to keep each group together.
- The company you work for is thinking of subscribing to various academic journals. Your task is to gather subscription information on these journals (normally found on the inside front or back cover). Go to the current periodicals section of the main library and record the annual institutional subscription rate (non-airmail where applicable) and the subscription address for the following ten journals (call numbers provided):

Utilitas	B 843.A1.U90	Journal of Social & Evolutionary Systems	GN 301.J91
Memory	BF 371.M5339	Camera Obscura	PN 1995.9.W6.C184
Infant Behaviour & Development	BF 723.I6.I439	New German Critique	PT 1.N535
Journal of Jewish Studies	BM 1.J89	The Lichenologist	QK 581. L700
Pacific Affairs	DU 1.P117a	Physiological Reviews	QP 1.P581

When completed place the materials back in the folder and place the folder in the completed task tray. "

Condition two:

"**TASK 1**

- A 13-page company report, typed (double spaced) on A4 paper is provided. Your task is to proofread it for spelling mistakes. Circle each spelling mistake that you find.
- The consumer research company you work for is currently interested in how people spend their holiday time. As part of this information gathering process you are required to write a two-page document describing what you did during the Christmas holidays.
- The company you work for is thinking of building or renting a new office. As part of this process they want to get quotes from relevant providers. Using the telephone book (yellow pages) provided look-up and record the names and phone numbers (response forms provided) of:

10 Builders	*10 Plumbers*
10 Real Estate Agents	*10 Concrete workers*
10 Civil Engineers	*10 Interior Decorators*
10 Roofing Contractors	*10 Architects*

When completed place the materials back in the folder and place the folder in the completed task tray.

TASK 2

- Twenty 'bills' (e.g., power bill, phone bill) are provided, along with an account balance sheet. Your task is to enter the 'billed amount' in the debt column and subtract the amount from the balance, creating a new balance after each subtraction (pen and paper subtraction - no calculator). *When completed place the materials back in the folder and place the folder in the completed task tray.*

TASK 3

- The company you work for has many job application letters, which it has received over the past 5 years. These need to be ordered and filed. The folder contains 100 job application letters. Firstly, you need to sort the letters with respect to the year they were sent. This will result in 5 groups of letters (1995, 1996, 1997, 1998, and 1999). For each of these 5 groups you are required to arrange the job applications in alphabetic order with respect to the applicant's surname (i.e. 'A' in the front, through to 'Z' at the back). The paper clips provided should be used to keep each group together. *When completed place the materials back in the folder and place the folder in the completed task tray.*

TASK 4

- The company you work for is thinking of subscribing to various academic journals. Your task is to gather subscription information on these journals (normally found on the inside front or back cover). Go to the current periodicals section of the main library and record the annual institutional subscription rate (non-airmail where applicable) and the subscription address for the following ten journals (call numbers provided):

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Journal of Jewish Studies	BM 1.J89	The Lichenologist	QK 581. L700
Pacific Affairs	DU 1.P117a	Physiological Reviews	QP 1.P581

When completed place the materials back in the folder and place the folder in the completed task tray. "

Task scheduling and completion

As in Experiment 3 participants were seated individually at a table, which contained: experimental instructions, task activity descriptions, a daily planner, four folders containing the task materials, a telephone directory, and a 'Completed Task' tray. Upon being seated each participant was directed to read the instructions, which was placed in front of them. These instructions were identical to those used in Experiment 3.

Like Experiment 3 the participant was required to schedule the completion of the four tasks using the daily planner. Once this was finished they completed the tasks in the sequential order they had chosen. Identical to Experiment 3 the researcher discretely recorded the time taken for the participant to complete each task. Upon completion participants were paid, debriefed, and thanked for their participation.

Results and Discussion

Hypothesis 1: The tendency to overestimate actual duration

The data was examined to determine the degree to which participants were able to estimate how long it would take to complete the three tasks which they where presented individually (as opposed to the three that were grouped together as 'one task'). Again, due to the crossover design used in this experiment only half of the participants provided individual time estimates for any particular task. The first and second numerical columns in Table 5 show the mean actual and estimated times for the completion of each task, the third numerical column shows the coefficient of variation of the estimation, the fourth the mean signed error (estimated minus actual duration), and the fifth numerical column shows the signed error as a proportion of the actual time taken.

Table 5. Summary of task duration estimation accuracy.

		Mean Time (&SDs) to Complete (Seconds)	Mean Estimated Time (&SDs) to Complete (Seconds)	Coefficient of Variation of Estimated Durations	Signed Error (Estimated Time - Actual)	Mean Difference as a Proportion ff Actual Time Taken	Proportion of Participants who Overestimated Actual Duration
Group 1 data n=20	1. Proofreading	1472 (552)	1425 (599)	0.420	-47	3%	50%
	2. Written Report	1339 (305)	1695 (844)	0.498	+356	26%	60%
	3. Contact Detail Look-up	1841 (430)	1518 (678)	0.447	-323	18%	40%
Group 2 data n=20	4. Balance Sheet	1332 (623)	1356 (589)	0.434	+24	2%	50%
	5. Order Documents	1125 (191)	1551 (619)	0.399	+426	38%	80%
	6. Library Subscription Details	2142 (418)	2175 (566)	0.260	+33	2%	60%
	All Six Tasks	9252 (991)	9720 (1939)	0.199	+468	5%	

In contrast to Experiment 3, the current experiment's mean signed errors (numerical column 4) are not positive for all six tasks. For two of the tasks the actual duration tended to be underestimated (proofreading & contact detail look-up). A more informative description of the pattern of over and underestimates is gained by looking at individual tendencies. The last column of Table 5 shows the proportion of participants who overestimated completion durations. The pattern of results appear similar to those found in Experiment 3 in that higher numbers of overestimation appear to be associated with shorter actual durations and vice versa. This pattern of results is consistent with the explanation given in Experiment 3.

Hypothesis 2 a & b: The tendency to report prototypical temporal values

By tabulating actual durations against estimated durations a convincing argument can be made that people tend to round their expected duration estimates to prototypical temporal values. Similar to Experiment 3's estimates, Figure 8 demonstrates that participants in this experiment tended to favour (potentially) prototypical temporal values like 10 15, 30, 40, 45, 50, 60 and 90 minutes (see the very top and very bottom rows of Figure 8. From looking at the pattern of estimation in Figure 8 it appears that participants are alternating between rounding to arithmetic prototypical values in the form of multiples of 10 and socially derived temporal prototypes such as ¼, ½, ¾ of an hour, 1hour and 1½ hours.

Estimated duration to the nearest minute

Actual duration to the nearest minute	5	7	9	10	12	15	17	20	25	30	35	40	45	50	60	80	83	90	100	120	Cumulative total of the number of completion times for each respective duration
12						1															1
13				2																	2
14								3	1	1		1									6
15				1		2		1													4
16						2		3	1	1		1									8
17								1		1		1									3
18						1		2		1				1							5
19						1		3		2		1									7
20					1	1		1		1											4
21		1		1		2		1							1						6
22				1		2		1		2		3									9
23								1		2											3
24				1		1	1			1											4
25										4											4
26						2				1											3
27	1					1						1			1						4
28										2			1								3
29										2	1	2									5
30								2		2		1									5
31												1									1
32									1	3											4
33			1					1	1	2		1									6
34						1		1				1									3
35												4	2	1							7
36										2											2
37															1						1
39						1				1											2
41								1													1
42										1											1
43												1									1
44										1											1
49												1									1
50								1			1										2
54									1												1
57										2											2
60										1											1
63														1							1
64													1		1						2
67															1						1
68															1				1		2
69															2			1			3
70													1								1
71																		1			1
72															1						1
73														1	1						2
75												1		1							2
76															1			1			2
77																		1			1
79										1			1	1							3
80															1						1
81															1						1
85															2						2
87										1					1						2
88															1						1
89															1						1
90										1											1
91																		1			1
100													1								1
104																	1				1
105												1									1
116																1					1
120																				1	1
Cumulative total of the number of estimates for each respective duration	1	1	1	6	1	18	1	23	5	39	2	22	7	6	18	1	1	5	1	1	160

Figure 8. A tabulation of all actual durations against estimated durations (note that the table has been collapsed where no actual or estimated durations occurred).

Further, it was predicted in Hypothesis 2b that in line with the tendency to report prototypical temporal values, there would be an inverse relationship between actual (& presumably estimated) duration and the coefficient of variability of the estimated duration. Similar to the result presented in Experiment 3 a significant (negative) Spearman rank order correlation of -.54 ($p < .05$) was found between the coefficient of variability of estimated durations and the actual durations of these estimates ($n=160$). Likewise, a significant (negative) Spearman rank order correlation of -.49 ($p < .05$) was found between the coefficient of variability of estimated durations and the relevant estimated durations ($n=160$). These findings provide support for the view that shorter tasks are associated with more variable estimates than relatively longer ones.

These correlations further strengthen the explanation put forward in Experiment 3 that this relationship is primarily due to the magnitude differences of the preferred prototypical temporal values as the duration of tasks increase. Specifically, as discussed earlier, because people appear to have a tendency to estimate prototypical temporal values there will be a larger magnitude of variation of estimates for shorter tasks.

Hypothesis 3: Evaluation of task grouping strategy

Half of the six tasks were grouped together and presented as 'one' task (the last three for group one and the first three for group two). It first needs to be shown that there was no significant difference between the groups and the first three and second three tasks as far as actual completion times were concerned so that comparisons can be made both between and within the two groups in respect to expected duration estimates.

The first numerical column of Table 6 shows the mean actual time it took participants to complete the first three, second three, and all six tasks for both groups. A 2x2 mixed design ANOVA, with group being the between subject variable, and whether the tasks were grouped together or not being the within subject variable, was conducted for the actual task durations. It revealed no main effect for group ($F(1, 38) = 2.91$, $p=.10$). This result confirms that the two groups did not differ significantly in the actual duration it took to complete all six tasks. Likewise, the ANOVA revealed no significant interaction between the group and chunking variables ($F(1, 38) = .40$, $p=.54$). However, it revealed a main effect for the chunking variable ($F(1, 38) = 9.49$, $p=.004$). To further analyse this effect a Post Hoc Tukey HSD test was undertaken, which revealed a significant difference ($p= .02$) between the average duration that group 1 took to complete tasks four, five, and six and group 2 to complete tasks one, two, and three (in both cases these were the tasks that were chunked together). Although this is not the ideal outcome it does not affect any of the important analyses concerning expected duration estimation (the difference in actual duration is between tasks that have been chunked together for both groups). Overall these results confirm that the important parts of balancing actual task duration for the first and second sets of three tasks had been successful. This means that, analysis of the effect chunking tasks together had on duration estimates could be undertaken both within and across the two groups of participants. This finding also reconfirms that grouping tasks together has no significant positive (or negative) effects on actual completion durations.

Table 6. Duration estimation accuracy data comparing chunked and non-chunked tasks

			Mean Time (&SDs) to Complete (Seconds)	Mean {& median} Estimated Time (&SDs) to Complete (Seconds)	Coefficient of Variation of Estimated Durations	Signed Error (Estimated – Actual Time)	Mean Difference as a Proportion of Actual Time Taken
Group 1	Presented separately	1.Proofreading, 2. Written Report, 3. Contact Detail Look-up	4653 (863)	4638 {4350} (1580)	0.341	+15	0.3%
	Chunked together	4. Balance Sheet, 5. Order Documents, 6. Library Subscription Details	4298 (609)	3540 {3600} (1347)	0.381	-758	18%
		All six tasks	**8951 (1219)**	**8178 (2601)**	**0.318**	**-773**	**9%**
Group 2	Chunked together	1. Proofreading, 2. Written Report, 3. Contact Detail Look-up	5134 (988)	3579 {3600} (1275)	0.356	-1555	30%
	Presented separately	4. Balance Sheet, 5. Order Documents, 6. Library Subscription Details	4599 (917)	5082 {5100} (1210)	0.238	+483	11%
		All six tasks	**9733 (1648)**	**8661 (2072)**	**0.239**	**-1072**	**11%**

Turning now to the main question at hand – the effect of task chunking on expected duration estimation accuracy – numerical column two of Table 6 shows the mean estimated times for the two conditions for each group. A 2x2 mixed design ANOVA, with group being the between subject variable and whether the tasks were chunked together or not being the within subject variable, was conducted for estimated task durations (see Figure 9).

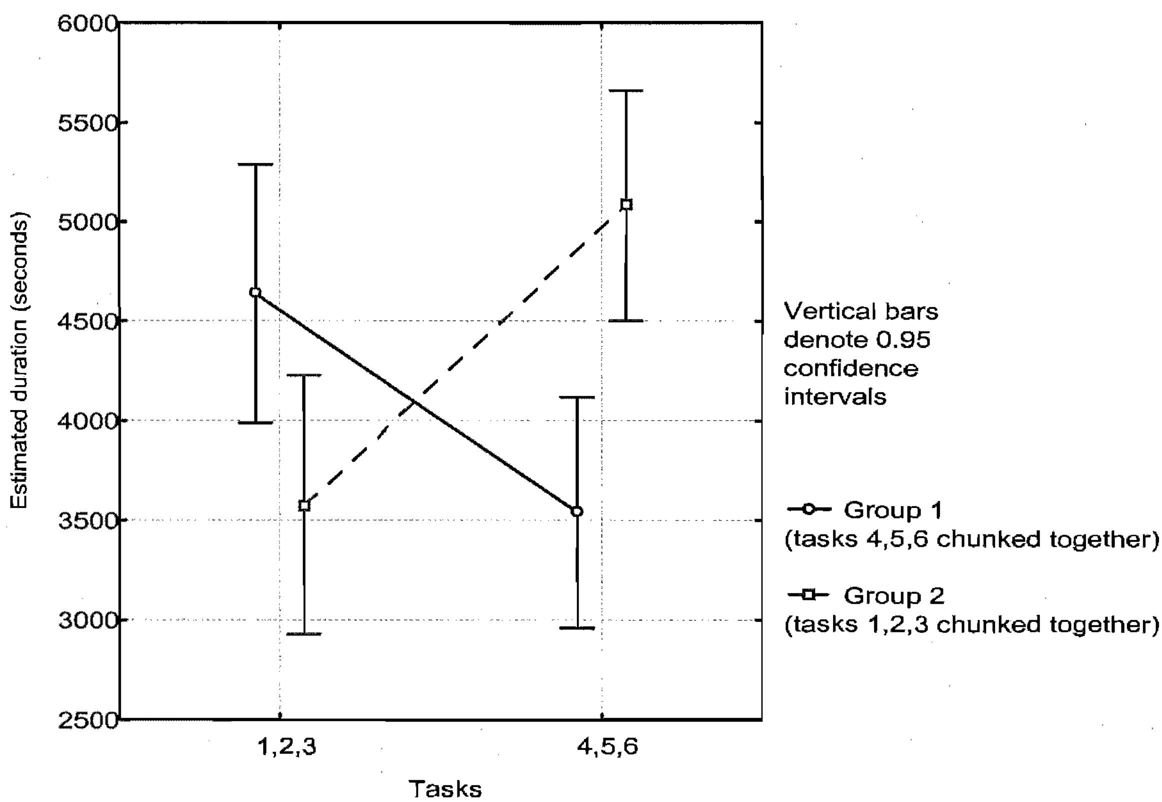

Figure 9. A graphical representation of the relationship between the two groups and chunked vs. non-chunked tasks

The results of the ANOVA revealed no main effect for group (F (1, 38) = .42, p=.52). This result confirms that the two groups did not differ significantly as far as overall duration estimated to complete all six tasks. In addition, it revealed no main effect for the chunking variable ($F(1, 38) = .88$, $p=.36$). As mentioned in Experiment 3, due to the crossover nature of the experimental design (for group one the second three tasks were chunked together whereas for group two it was the first three) a non-significant result was expected. However, as expected, the ANOVA revealed a significant interaction between the group and chunking variables ($F(1, 38) = 36.16$, $p=.0000$). More specifically, planned comparisons revealed significant differences between the two groups on their duration estimates for tasks one, two, and three ($F(1, 38) = 5.44$, $p=.03$), tasks four, five, and six ($F(1,38) = 14.5$, $p= .000$), group one's estimation of tasks one, two, and three and tasks four, five, and six ($F(1, 38) = 12.89$, $p=.001$), and similarly group two's estimation of tasks one, two, and three and tasks four, five, and six ($F(1, 38) = 24.15$, $p=.000$). This finding replicates the finding of Experiment 3 whereby chunking tasks together had a significant effect on expected duration estimates.

In contrast to Experiment 3, this reduction in estimated duration did not result in increased accuracy of the estimations (see numerical columns 4 & 5 of Table 6). In fact when presented separately these somewhat longer tasks were estimated with a relatively high degree of accuracy. Whereas chunking tasks together resulted in greater error – specifically underestimation of actual duration.

Chapter 8

General conclusions

The concluding chapter will begin by briefly summarising my process model of expected duration estimation, pointing out which linkages/components of the model have received empirical support from the four experiments conducted as part of this thesis. The second part of the chapter will discuss the findings of these experiments in relation to time management, specifically task scheduling.

The general thrust of my model outlined earlier in Figure 4, is that people will attempt to estimate the expected duration of an upcoming event or task by 'reflecting' back upon memories of similar tasks. It is argued that this 'reflection' will often involve reconstructing event/s from memory traces (Burt & Kemp, 1994). Additionally, it is argued that although these remembered events may be 'reconstructed' they will often appear to be a verisimilar representation (Michon, 1990) of a specific event.

The process of making an expected duration estimate begins by 'searching' autobiographical and/or semantic memory for useful memory traces that can be reconstructed into useable memories. It was argued that useful autobiographical memory traces are likely to be cued at varying levels of specificity. Drawing upon the work of Conway and Pleydell-Pearce (2000), three levels of specificity were identified as potentially providing useful information. At the broadest level are memories that contain thematic knowledge concerning a period of a person's life. At the next level of specificity are those memories that are made up of a collage of similar events. Finally, at the most specific level, and of most direct utility to providing duration estimates, are vivid memories of a specific event, and what Conway and Pleydell-Pearce (2000) refer to as 'event-specific knowledge'. Importantly for the present focus, memories at lower levels of specificity are likely to cue more specific and useful memories (Conway & Pleydell-Pearce, 2000).

These memories are presumed to be categorised in relation to their usefulness or similarity to the to-be-estimated task or event. Task relevant semantic knowledge is likely to be utilised in this categorisation process. For example, a person who is required to estimate how long it is going to take them to deliver a package across town during peak time is likely to draw upon their understanding of the term 'peak time', and categorise memories of driving across town during early afternoon as being less relevant/useful than memories of where they travelled at 5pm.

It is also argued that the reconstructed events will often be in the form of schematic event memories rather than reconstructions of a specific event (Michon, 1998; Schank, 1999). Experiment 1 addressed an aspect of these schematic event memories – specifically the effect that presenting a highly salient similar to-be-estimated task has on a subsequent task estimate. The results of this experiment could be interpreted as suggesting that schematic event memories can potentially be 'adjusted' with a single presentation of a similar task. It was tentatively argued that it was the saliency of the single presentation which effected the following estimation: if participants were required to estimate the completion of the similar task a day or two before, rather than immediately before, it would not have had such a large effect (if any) on their estimate. Furthermore, following on from this interpretation, the 'up-dating' of schematic event memories appear to occur even when the person has not actually 'experienced' the event firsthand – which is inline with the reconstructive process involving a verisimilar representation advocated in Chapter 4.

Connected to this process of reconstructing useful events from memory is the estimation of how long these event/s took? It is suggested that this temporal information can be derived through two potentially complementary yet distinct methods – through memory of 'clock time' of the referent event or reconstructing the duration from the referent memory. Firstly, as clocks and watches are so pervasive in modern society it is argued that temporal aspects of the day (especially in work situations) are often encoded directly into memory. Secondly, there are probably just as many situations where the temporal estimate will be based on 'subjective time' (Boltz, 1998b) derived from reconstructions of remembered events or tasks (which are most likely schematic in nature).

Lastly, the model suggests that the 'raw' estimate is likely to be 'adjusted' by two different moderators. Firstly, it is suggested that internally or externally derived temporal boundaries will influence the estimate either up or down depending upon the nature of the temporal boundary. Experiment 2 demonstrated that externally derived temporal boundaries effect expected duration estimates – even when they are remote in nature. Secondly, the model suggests that because an estimate is likely to be inexact, it will be rounded affecting the accuracy of the final estimate. Furthermore, this rounding will often result in the estimator favouring prototypical temporal values. Experiments 3 and 4 provided support for this rounding and the use of prototypical temporal values.

Below, the findings of all four experiments are discussed in relation to the scheduling of tasks as part of the time management process.

The results in Experiment 1 demonstrated that the scheduling of an earlier similar task can affect the amount of time allocated to a task. It has been suggested that this effect could be due to an updating of schematic event memory, in that the process of estimating the duration of the first task potentially affects memory in a similar way to actually having completed it. Although a lot more research is needed to fully understand the role schematic event memory plays in expected duration estimation, it is interesting to speculate whether it may be feasible to develop an algorithm for scheduling software that could 'measure' the degree of task typicality and adjust the estimate accordingly. Such an algorithm would need to effectively classify tasks (both type and temporal magnitude) and 'predict' individual response biases in relation to the tasks' typicality (probably based on a combination of the number of exposures and relative saliency of a similar 'class' of task). The measure of typicality would be developed over time by recording and analysing the effectiveness of previous scheduling. To be truly effective it would also have to take into account the person's awareness of the degree of typicality in relation to their schematic event memory for that 'type' of task (i.e. is the person already adjusting the estimate appropriately?). Again, this would need to be achieved by recording and analysing the effectiveness of previous scheduling.

Additionally, one of the interesting and largely unexplained processes evident in Experiments 3 and 4 (and most other estimation research) is that people appear to be able to choose and adjust the temporal 'scale' of their expected duration estimation. Specifically, whereas five minute chunks seem to be the standard for Experiment 3 (Figure 6), quarter-hour chunks seem to become the dominant scale as the tasks get longer in Experiment 4 (Figure 8). Given the difficulty of making expected duration estimates it is somewhat surprising estimators are as effective as they are at choosing an appropriate scale. It is argued that this choice involves, along with other task and estimator variables (such as experience at making duration estimates and temporal bounding effects), an analysis of the task typicality in relation to the person's schematic event memory for that type of task. Similarly, the pattern of results may partly be a consequence of people choosing their scale values based on the first task. Therefore, if a short task is first then people will use a smaller scale/prototypical temporal value, meaning they will tend to allocate less time for the following longer task, and vice versa for long tasks that are first.

Experiment 2 suggested, in contrast to most other research in the area, that temporal boundaries (even remote ones) can be useful in directing/constraining a person's expected duration estimation. What does this result suggest about the facilitation of accurate expected duration estimation when used as part of the scheduling process? It is argued that there clearly needs to be appropriate boundary information provided to the person to ensure accurate expected duration estimation (to avoid large overestimates of actual duration). Although it is acknowledged that nearly all real-world scheduling is undertaken with the aid (or hindrance!) of some kind of temporal boundary, it is argued that on the whole these boundaries are inappropriate – they inhibit accuracy instead of facilitating it. For instance, in work situations temporal boundaries imposed on the task scheduler tend to be pragmatic in nature (e.g., the PowerPoint presentation needs to be completed by Monday a 11am because that is when it is required in order for Mike to be able to conduct his seminar) rather than reflective of the nature and/or likely duration of the task.

Typically, the most salient temporal boundary in a work situation will be in the form of a completion deadline. Although this deadline potentially may provide directive feedback of the potential required duration, on the whole it will be externally imposed (not necessarily a bad thing) and have no logical or temporal connection to the actual potential duration of the task.

How could this situation be improved? Potentially the most effective way to provide appropriate temporal boundary prompting would be by utilising scheduling software. It may be possible to develop an algorithm that takes into account individual and task variables and, based on past success at estimating the duration of previous similar tasks, provide appropriate boundary prompts. Specifically, this could take the form of a maximum duration or range. Additionally, it will probably include a selection of an appropriate temporal segmentation (made by the software) in order to help 'enforce' appropriate boundaries (Burt & Forsyth, 1999).

More research will be required to determine the exact form that this prompting would take. The difficultly will be identifying the most appropriate boundary scale and saliency. It is likely that un-weighted temporal data from estimating previous similar tasks may impose too tight a boundary, resulting in underestimation of the upcoming tasks' actual duration. It is likely that a weighted temporal value (or more likely a range) will result in the most effective feedback. The actual weighting is likely to vary with actual durations of the upcoming tasks and across different people. Additionally, the level of saliency of the prompt will be an important variable to determine. It is most likely that the person scheduling the task will have a more intermit understanding of the to-be-completed task, so the boundary prompt should not override this potentially useful information. Alternatively, the prompt will need to be salient enough to have the desired effect of facilitating accurate duration estimates. As with the issue of scale, there is likely to be both individual and task specific differences to the required saliency.

However that said, there are many lower-tech strategies that could be utilised to improve the effectiveness of temporal boundaries. For example, supervisors and managers could be trained to provide more appropriate 'deadlines' when assigning work to their incumbents. Alternatively, the idea put forward by Burt and Forsyth (1999) concerning the development of scheduling materials, which reflect the requirement of the specific types of tasks generally carried out by the person, could also be developed in a way for these materials to provide useful temporal boundaries.

Before moving on to the final two experiments it is worth pointing out a potential confound in Experiment 2. Whereas the two shorter temporally bounded scenarios required that the estimator imagine that they had just arrived for work (day not specified), the longest temporally bounded scenario required that they imagine that they had just arrived for work on Monday morning. Although it is my view that this difference did not confound the results, it is a possibility worth mentioning. It could be argued that inclusion of 'Monday morning' in the longest temporal boundary scenario led participants to believe that they had more time than the other scenarios. Therefore, in hindsight, it may have been more appropriate to have all three scenarios beginning on Monday morning.

Experiments 3 and 4 suggested that people tend to report prototypical duration values when making expected estimates – these two experiments suggest somewhere in the magnitude of between 70 and 85 per cent of estimates could be expected to be of this sort. Secondly, this bias has a significant effect on the accuracy of expected duration estimates.

As far as the relatively short duration individual tasks used in Experiment 3 were concerned, there tended to be an inverse relationship between the degree of overestimation and the actual task duration. It was suggested that this was predominately caused by the tendency for participants to provide prototypical estimation values (in this case five minutes). Further, chunking the tasks in lots of three resulted in more accurate duration estimates. Again, this was explained by the tendency to report prototypical values, which in this case resulted in the participant being able to provide a more 'fine-grained' estimation for the longer actual duration of the three chunked together tasks.

The findings from Experiment 3 are most relevant for people who are required to complete numerous short duration tasks. For example, individuals undertaking secretarial work are continually required to undertake a multitude of 'small' tasks. Teaching these individuals to identify and chunk together appropriate short duration tasks may facilitate scheduling the completion of such tasks. An effective way to achieve this may be to develop software that prompts the user when they should chunk tasks together.

A similar pattern of results, in respect to the predisposition to report prototypical temporal values, was found in Experiment 4 using somewhat longer tasks. However, overall there was less overestimation (in fact on average some tasks were underestimated), which is to be expected if people are relying on similar magnitude (i.e., five minutes or even 10 minutes) prototypical values reported in Experiment 3, whereby participants have a real choice of estimates both below and above the actual duration. Further, as in Experiment 3 there tended to be an inverse relationship between overestimation and actual duration. Similar to Experiment 3, grouping three of the tasks together resulted in significantly less estimated duration. However, unlike Experiment 3 this resulted in less accurate estimation. Unlike the shorter tasks used in Experiment 3 it appears that these somewhat longer tasks will be most efficiently scheduled individually rather than being chunked together, although further replication of this finding is required.

There are many questions concerning the tendency to report prototypical values that these two experiments do not adequately answer. For example, is it possible to predict which prototypical values people will favour? Similarly, how do people choose the magnitude of the prototypical value they will use (Experiments 3 & 4 suggest that there is quite a lot of consistency across participants on this matter)? Another important issue is whether the pattern of reporting observed in these two experiments represent a number of different prototypical values (i.e., 5, 10, 15, 30) that are common in our culture, or do they represent multiples of a single (or a few) prototypical values (i.e., five minutes)? Although these studies can not adequately answer this question it is interesting to note the relatively high number of 40 minute estimates as opposed to 45 minute ones in Experiment 4 (see Figure 8), which points to a 'multiple-of' prototype scenario (whereas 'three quarters of an hour' is a popular prototypical temporal value in our culture, 40 minutes is not). The reality is probably a combination of both.

Additionally, the tendency for people to estimate prototypical temporal values may be helpful in explaining some of the variation found in expected duration studies to date. For example as mentioned earlier, unlike many other similar studies (e.g., Burt & Kemp, 1994) Francis-Smythe and Robertson's (1999) expected duration estimation experiment did not find evidence of a general trend towards overestimation in relatively short duration tasks. This lack of relative overestimation may be partly explained by the effect of the rounding of estimates to prototypical temporal values. As the single task used for the expected duration estimation had a median actual duration a little over the prototypical value (five minutes), it is probably not surprising that there was less overestimation than in previous similar studies (e.g., Burt & Kemp, 1994).

Although more research needs to be undertaken to fully understand the rounding of estimates to prototypical temporal values, a number of issues can be discussed based on the findings of Experiments 3 and 4. Following is a discussion of the possible reasons why people appear to favour prototypical temporal values (and choose their scale), and some recommendations for increasing the accuracy of expected duration estimation where prototypical temporal values are reported.

Why do people tend to round their estimates to prototypical temporal values and how do they choose the temporal scale? Firstly as Artieda and Pastor (1996, p.12) point out, "our perception of time is always relative to our experience of the duration of a temporal unit (a second, a minute etc.)". Specifically, the threshold of discrimination comparison of the relative durations of two intervals is dependent on their objective duration. It is all a matter of scale - whereas a person is likely to be able to discriminate between a duration lasting two minutes and one lasting three minutes, it is unlikely they could successfully do the same for a duration lasting 40 minutes and one lasting 41 minutes, even though the difference between the two durations is the same in both examples – one minute.

Likewise, as outlined above, the prototypical temporal values found in these studies are values that are repeatedly used and reinforced in our culture, so gaining their prototypicality - they are learned ways of representing temporal category information. In their study of autobiographical memory Huttenlocher, Hedges, Bradburn (1990) suggest that the over-representation of prototype values, which stand for a larger category, occur primarily when memory for the duration is inexact. Clearly the same type of reasoning can be applied here with expected duration. In fact, there should be a greater use of these prototypes given the fact that not only are the estimates most likely based on an inexact memory of an event, it is most likely that the event will not be an exact facsimile of the expected task. There is some support for this view from Experiments 3 and 4. Whereas only 70 per cent of estimates from Huttenlocher, et al.'s (1990) retrospective duration estimation studies could be categorised as being prototypical values, in Experiment 3 and 4, respectively, 73 and 83 per cent of duration estimates were in the form of prototypical values.

In a related issue, Yarmey (2000) interestingly uses the fact that people tend to round durations to suggest that relatively long durations, greater than 10 minutes or so, must represent reconstructions of likely time spans rather than accurate recapitulation He suggests that in his study people appeared to round these longer durations to minutes ending in zero or five - unlike the shorter durations which may be a recapitulation of the actual event because this rounding was not evident.

However it is suggested that his reasoning may be flawed, and that in fact the relative magnitude of rounding is similar for relatively short and long duration tasks - although this is not obvious when comparing duration estimates which vary in scale from a few seconds to many minutes. Specifically, rather than rounding to minutes ending in zero or five, shorter duration estimates in some cases may be rounded to the nearest minute.

Shifting attention to the value of chunking tasks together as a strategy to reduce the effect of rounding estimates to prototypical temporal values, Experiment 3 and 4 suggested that tasks of certain durations should be chunked together for scheduling purposes whereas others might need to be split up. Specifically, these experiments suggested that it may be useful to chunk together a number of relatively short duration tasks (e.g., less than five minutes) for scheduling purposes. Alternatively, for longer tasks (e.g., one –one and half hours) more accurate duration estimation may be achieved by, where possible, splitting the task up into sub-components for scheduling purposes.

How would this be done? After all if the person knows how long the task is going to take there will not be a problem to estimate its duration. To a certain extent this is true, however it is argued that as most people carry out reasonably similar tasks in their day-to-day work they should be able to decide (if given the proper guidance) whether to group, split, or leave the to-be-scheduled task when making an expected duration estimation. Alternatively, scheduling software could be developed to prompt the person to undertake one or other of the three possible strategies based on past experience of various similar tasks. It is worth noting at this point that, as with most computerised initiatives suggested here, there is a requirement that the person provides feedback on the relative success of past duration estimates.

Further, in relation to the view put forward above concerning the potential overriding ability of the scheduler segmentation, it may be the case that people should be encouraged to group tasks together in ways that are appropriate for their particular daily scheduler segmentation.

Finally, there is a third and potentially useful way to overcome the local biasing effects of the tendency to rely on prototypical durations – expected duration estimates could be 'corrected' so as to account for this biasing effect. In support of this possibility, Hartley et al. (1977) suggest that if a common response bias could be effectively identified (i.e., consistently over or underestimate) it could be corrected by statistical means. This process is a real possibility with the proliferation of computerised schedulers that have the potential to make this correction automatic. It is likely that, similar to what has been mentioned earlier, software would need to undergo a substantial 'learning' period concerning the individual's idiosyncrasies using prototypical duration estimates, while at the same time receiving feedback on the accuracy of past expected duration estimates. That said, such statistical corrections remain an interesting possibility for not only the biasing effect of prototypical durations but for all ‘regularly’ occurring biases.

In conclusion, this thesis has attempted to provide a greater understanding of expected duration estimation. It has used the scheduling component of the time management process as a real-world situation in which to develop a process model of expected duration estimation, and to test some of the components of that model. Although many of the components in the proposed model are yet to be directly empirically validated, it is intended that the model and associated research presented in this thesis will provide an effective platform for further investigation into this interesting, complex, and pertinent topic.

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Appendix 1

Experiment 1 stimuli

You are invited to participate in a study which requires you to estimate how long you think it will take you to complete the tasks in the four following scenarios. Please read the descriptions carefully before making your estimation

Age .... **Gender: female / male**

Task 1

Five 'bills' (e.g., power bill, phone bill) are provided, along with an account balance sheet. Your task is to enter the 'billed amount' in the debt column and subtract the amount from the balance, creating a new balance after each subtraction (pen and paper subtraction - no calculator). How long do you think this is going to take you?

Estimated time to complete: ....

Task 2

Twenty 'bills' (e.g., power bill, phone bill) are provided, along with an account balance sheet. Your task is to enter the 'billed amount' in the debt column and subtract the amount from the balance, creating a new balance after each subtraction (pen and paper subtraction - no calculator). How long do you think this is going to take you?

Estimated time to complete: ....

Task 3

A three-page document typed (double-spaced) on A4 paper is provided. Your task is to proofread it for spelling mistakes. Circle each spelling mistake that you find. How long do you think this is going to take you?

Estimated time to complete: ....

Task 4

A 13-page document typed (double spaced) on A4 paper is provided. Your task is to proofread it for spelling mistakes. Circle each spelling mistake that you find. How long do you think this is going to take you?

Estimated time to complete: ....

Thank you, for your valuable participation.

You are invited to participate in a study which requires you to estimate how long you think it will take you to complete the tasks in the four following scenarios. Please read the descriptions carefully before making your estimation

Age .... **Gender: female / male**

Task 1

Twenty 'bills' (e.g., power bill, phone bill) are provided, along with an account balance sheet. Your task is to enter the 'billed amount' in the debt column and subtract the amount from the balance, creating a new balance after each subtraction (pen and paper subtraction - no calculator). How long do you think this is going to take you?

Estimated time to complete: ....

Task 2

Five 'bills' (e.g., power bill, phone bill) are provided, along with an account balance sheet. Your task is to enter the 'billed amount' in the debt column and subtract the amount from the balance, creating a new balance after each subtraction (pen and paper subtraction - no calculator). How long do you think this is going to take you?

Estimated time to complete: ....

Task 3

A 13-page document typed (double spaced) on A4 paper is provided. Your task is to proofread it for spelling mistakes. Circle each spelling mistake that you find. How long do you think this is going to take you?

Estimated time to complete: ....

Task 4

A three-page document typed (double-spaced) on A4 paper is provided. Your task is to proofread it for spelling mistakes. Circle each spelling mistake that you find. How long do you think this is going to take you?

Estimated time to complete: ....

Thank you, for your valuable participation.

Appendix 2

Experiment 2 stimuli

You are invited to participate in a study which requires you to estimate how long you think it will take you to complete the tasks in the three following scenarios. Please read the descriptions carefully before making your estimation

Age .... **Gender: female / male**

Task 1

Imagine that you have just arrived at work and your boss approaches you with a task which she would like completed before morning tea time. What she would like you to do is to proofread for spelling mistakes a thirteen page company report (A4, typed, and double spaced). How long do you think it is going to take you?

Estimated time to complete: ....

Task 2

Imagine that you have just arrived at work and your boss approaches you with a task which they would like completed before lunch time. The company you work for is thinking of building a new factory. As part of this process your boss wants you to record the contact details of relevant providers so quotes can be requested at a later date. Using the yellow pages of the telephone book you need to look-up and record the names and phone numbers of:

10 Builders	*10 Plumbers*
10 Real Estate Agents	*10 Concrete workers*
10 Civil Engineers	*10 Interior Decorators*
10 Roofing Contractors	*10 Architects*

How long do you think this is going to take you?

Estimated time to complete: ....

Task 3

Imagine that it's Monday morning and you have just arrived at work and your boss approaches you with a task which they would like completed by the end of the week. The task involves entering ten invoices into the company balance sheet (e.g., power bill, phone bill). You will need to enter the 'billed amount' in the debt column and subtract the amount from the balance, creating a new balance after each subtraction (pen and paper subtraction - no calculator). How long do you think this is going to take you?

Estimated time to complete: ....

Thank you, for your valuable participation.

You are invited to participate in a study which requires you to estimate how long you think it will take you to complete the tasks in the three following scenarios. Please read the descriptions carefully before making your estimation

Age ……… **Gender: female / male**

Task 1

Imagine that it's Monday morning and you have just arrived at work and your boss approaches you with a task which she would like completed by the end of the week. What she would like you to do is to proofread for spelling mistakes a thirteen page company report (A4, typed, and double spaced). How long do you think it is going to take you?

Estimated time to complete: …………….

Task 2

Imagine that you have just arrived at work and your boss approaches you with a task which she would like completed before morning tea time. The company you work for is thinking of building a new factory. As part of this process your boss wants you to record the contact details of relevant providers so quotes can be requested at a later date. Using the yellow pages of the telephone book you need to look-up and record the names and phone numbers of:

10 Builders	*10 Plumbers*
10 Real Estate Agents	*10 Concrete workers*
10 Civil Engineers	*10 Interior Decorators*
10 Roofing Contractors	*10 Architects*

How long do you think this is going to take you?

Estimated time to complete: …………….

Task 3

Imagine that you have just arrived at work and your boss approaches you with a task which they would like completed before lunch time. The task involves entering ten invoices into the company balance sheet (e.g., power bill, phone bill). You will need to enter the 'billed amount' in the debt column and subtract the amount from the balance, creating a new balance after each subtraction (pen and paper subtraction - no calculator). How long do you think this is going to take you?

Estimated time to complete: …………….

Thank you, for your valuable participation.

You are invited to participate in a study which requires you to estimate how long you think it will take you to complete the tasks in the three following scenarios. Please read the descriptions carefully before making your estimation

Age .... **Gender: female / male**

Task 1

Imagine that you have just arrived at work and your boss approaches you with a task which they would like completed before lunch time. What she would like you to do is to proofread for spelling mistakes a thirteen page company report (A4, typed, and double spaced). How long do you think it is going to take you?

Estimated time to complete: ....

Task 2

Imagine that it's Monday morning and you have just arrived at work and your boss approaches you with a task which she would like completed by the end of the week. The company you work for is thinking of building a new factory. As part of this process your boss wants you to record the contact details of relevant providers so quotes can be requested at a later date. Using the yellow pages of the telephone book you need to look-up and record the names and phone numbers of:

10 Builders *10 Plumbers*
10 Real Estate Agents *10 Concrete workers*
10 Civil Engineers *10 Interior Decorators*
10 Roofing Contractors *10 Architects*

How long do you think this is going to take you?

Estimated time to complete: ....

Task 3

Imagine that you have just arrived at work and your boss approaches you with a task which she would like completed before morning tea time. The task involves entering ten invoices into the company balance sheet (e.g., power bill, phone bill). You will need to enter the 'billed amount' in the debt column and subtract the amount from the balance, creating a new balance after each subtraction (pen and paper subtraction - no calculator). How long do you think this is going to take you?

Estimated time to complete: ....

Thank you, for your valuable participation.

Appendix 3

Experiment 3 & 4 'Daily Planner'

Daily Planner